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UNIVERSITY OF IOWA STUDIES IN
CHILD WELFARE

UNIV. OF
CALIFORNIA

Professor Bird T. Baldwin, Ph. D., Editor

From the Iowa Child Welfare Research Station.

Volume I

Number I

THE PHYSICAL GROWTH OF CHILDREN
FROM BIRTH TO MATURITY

by

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CHAPTER II

ANTHROPOMETRIC INSTRUMENTS AND METHODS OF MEASURING

The international standardization of instruments and methods for taking measurements on living subjects is of paramount importance in the securing of comparable data for the science of physical growth. The Iowa Child Welfare Research Station has established through cooperation and collaboration with other scientific organizations and laboratories, standard instruments, accurate technique and uniformity of anthropometric methods within the fields limited to child development. Since the establishment of the Station there has been close cooperation with some of the leading anthropometrists in America, especially with the division of anthropology of the National Research Council, and the United States National Museum of the Smithsonian Institution, Washington, D.C. Dr. A. Hrdlicka spent one week at the Station assisting in formulating methods of procedure for the anthropometric work. It has been through his co-operation that the compasses and calipers have been obtained. The other instruments have been made in the University shops, under the writer's direction. The aim has been to secure:

- (1) Instruments with accurate units of measure in the metric system.
- (2) Light, convenient, portable instruments of non-expandable material and simple design.
- (3) Uniformity in standards of technique for measuring.
- (4) The acceptance of definite land-marks for determining measurements.

1. Instruments

a. The Paper Measuring Scale. This type of plane, which is a modification of the plane of Broca, was originally suggested by the Committee on Anthropology of the National Research Council; it has been modified by the writer and printed by a local printer. The plane consists of a strip of the best type of inextensible and unshrinkable paper, one meter long and twelve and a half centimeters broad, with the metric divisions on the right edge of the scale in centimeters and millimeters, and the English on the left edge in feet, inches and fifths of an inch, and with a margin on each side of the scale and also at the top and bottom. An attempt was made to have a plate made from the scale as drawn by a draftsman, but this plan was abandoned, and the printed scale was substituted. Since the slugs used in printing are a little less than .5 mm. in thickness and the width of the line introduces a constant error, it was necessary to use strips of thin tissue paper between the separate slugs and to measure each millimeter distance accurately as a unit.

The paper plane has been used for several months and there has been no appreciable shrinkage under usual weather conditions. The chief advantages of the scale are that it is portable, may be sent through the mail, and is easily tacked or pasted to a wall or a specially prepared board. The position can be standardized, which is not possible with a rod.

The five millimeter unit has been used in place of the one millimeter, as the examiner soon becomes able to estimate the millimeters accurately, the reading is less fatiguing to the eyes and there is an added interest in the estimation of each particular case for measurement. The paper plane in the vertical position is used in measuring standing height and height sitting and in the horizontal position for the span of arms.

b. The Square. The square consists of two pieces of seasoned walnut 18cm. by 13 cm., joined at right angles. On the inside of the median line

 

is a narrow strip 5mm. thick, in which is cut an opening that serves as a handle. The square which is used for the three measurements just stated above was constructed in the University Shops.

c. The Bench. The bench, also constructed in the University Shops, is used for height sitting. It is made of thoroughly seasoned walnut. Two sizes have been adopted, one 30 cm. in height by 30 cm. square, the other 40 cm. in height by 40 cm. square. For adults, it is recommended that a third size, 50 cm. square be used.

d. Large Sliding Calipers. The large sliding caliper is the Hrdlicka compass made in Washington for the Research Station and tested by the Bureau of Standards. This compass has also been made by Collin in Paris. The caliper consists of a hollow rod, 70 cm. long, 2.2cm. broad and 0.8 cm. thick, made of well nicked and welded brass strips; and of aluminum branches, 26 cm. long (in the free) and 3.5 cm. broad. It is light, very serviceable durable, easy-working, and accurate.

e. Small Sliding Calipers. The sliding caliper (compas glissiere) was made in Washington and tested by the Bureau of Standards. This is the Collin Compass and is accurately and well designed.

f. Spreading Calipers. The calipers in use are the Hrdlicka type, made by Dr. Ballauf, Washington, first made by Collin in 1912. The terminal parts are in a straight line at the spread of 10 cm. There is a guard on the lower portion of each branch 8 mm. from the point, to regulate the distance of introduction into the meatus. The resulting instrument is but imperceptibly heavier than the older standard compass of Mathieu; it serves with equal facility the same purposes.

g. Tapes. On account of the delay in receiving linen tapes from Paris, the ordinary millimeter steel tape is used. It has several disadvantages, a linen tape of non-elastic material being preferable.

h. Scales. The scale in use in the anthropometric laboratory is the Buffalo type with pillar 3'3" high, on wheels, beam being triple bar. On one side:

- Top bar is marked 100 (50 kilo graduation)
- Middle bar is marked 50 (5 kilo graduation)
- Lower bar is marked 5 (1/20 kilo graduation)

On other side:

- Top bar is marked 200 (100 pound graduation)
- Middle bar is marked 100 (10 pound graduation)
- Lower bar is marked 10 (1/10 pound graduation)

This scale is accurate, portable from room to room but heavy for transportation.

i. Dynamometer. So far the Smedley hand dynamometer sold by Stoelting has been used, but the Collin instrument will be substituted as soon as it is received from abroad. The "Martin Method" which uses the spring balance scales is also being tested out.

j. Wet Spirometer. No spring spirometer has been found to be accurate. The Stoelting model is used. This apparatus is too familiar to warrant description here.

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k. Measuring Board for Infants. The accompanying photograph shows a new measuring scale for determining the reclining length and reclining sitting height of infants. It was designed by the writer and made in the manual training shop of the University. The scale is one meter in length, with an additional margin of 4.5 centimeters at the one end. The width is 20.5 centimeters, with standardized buttonwood millimeter scales on either side. The vertical plane for the head rest is 15 centimeters at its greatest height, and the sliding vertical plane is attached to a brass rod which moves freely in a brass groove in such a manner that the millimeter reading may be taken from either side. The board is made of inlaid walnut and buttonwood and the standards on which it rests when in contact with the table, are covered with heavy felt. The scale is accurate and portable.

2. Measurements Taken.

For purposes of determining the physical development of children from birth to maturity the following list of measurement has been selected for use in the anthropometric department of the Research Laboratory.

- A. Length
 - 1. Standing
 - 2. Sitting
 - 3. Span of arms
 - 4. Upper arms (shoulder-elbow)
 - 5. Forearm (elbow-finger tip)
 - 6. Lower leg
 - 7. Face
- B. Width
 - 8. Shoulder
 - 9. Hips
 - 10. Face
- C. Diameter.
 - 11. Head (anterior-posterior)
 - 12. Head (transverse)
 - 13. Head (height)
 - 14. Chest;(width)
 - 15. Chest (depth)
- D. Circumference
 - 16. Head
 - 17. Chest
- E. Weight
 - 18. Body weight
- F. Breathing Capacity
 - 19. Lung capacity minus residual air
- G. Strength
 - 20. Strength of right forearm
 - 21. Strength of left forearm
 - 22. Strength of wrist-right and left
 - 23. Strength of elbow-right and left
- H. Indices
 - 24. Sitting-standing
 - 25. Cephalic-index
 - 26. Chest-index
 - 27. Vital
 - 28. Weight-index
- I. Cranial capacity

3. Methods

A. Length

(1) Standing Height. This measurement is made with the Research Station Paper Measuring Scale previously described, and the wooden square. The subject stand straight with heels together, and heels, buttock, upper part of back (and generally the head) against the wall to which the scale is attached. The arms are extended at the side in a natural position and the head is in such a position that the visual and biauricular axes are horizontal. The square may be held in either hand. If held in the left hand the readings are taken from the right margin of the plane and if held in the right hand, from the left margin of the plane. The square is brought down firmly two or three times in succession on the top of the head, with sufficient force to feel the impact of the skull, and the reading taken from the last position.

(2) Sitting Height. For the measurements of the sitting height, the Geneva agreement has been followed which recommends: "The subject sits on a horizontal and resisting seat (bench) about 30 to 40 cm. high (this height being proportionate to the stature of the subject): the knees are flexed; the dorsal aspect of the trunk is to make contact with the vertical plane or with the anthropometric rod or plane at two points viz., at the sacral region and again between or at the shoulder blades. The axis of vision is horizontal. The height of the vertex above the surface of the seat is to be measured." (406 p. 64.)

(3) Span of Arms. This measurement is the distance from the tip of the middle finger (medius) of the left hand to the tip of the middle finger (medius) of the right hand with maximum extension of the arms when the subject is standing in a normal position, similar to the position required for standing height, against a plane background. The child's left middle finger touches a vertical wall or moulding and the right extends over the paper plane placed in a horizontal position at a level with the child's shoulders with the fingers rigid. The two arms are extended and after the right arm (free arm) has been raised in a line with the left the observer applies the square lightly against the free end of the middle finger of left hand and reads the greatest distance recorded, noting that both fingers are simultaneously in contact with the terminal limits.

(4) Upper Arms. The large sliding calipers are used. The elbow is flexed and the terminal points are the acromion at the shoulder and the external condyle of the humerus at the elbow.

(5) Forearms. The large sliding calipers are used to find the distance from the olecranon process of the elbow to the finger tip, with the elbow flexed at right angles in front of the subject and with palmar side up. This measurement varies with the two arms and the position of the arm. It is being standardized by Mr. Howard R. Mayberry of the Station.

(6) Lower Leg. This measurement is from the knee to the sole of the foot when the knee is flexed at right angles. The measurement is made with the large sliding calipers.

(7) Face. The length of the face is taken with the spreading calipers from the nasion (the mid-point of the naso-frontal suture) to the lowest point of the chin.

(8) Shoulders. The large sliding calipers are used for finding the distance between the two great prominent tuberosities of the humerus bones below the acromion processes. The arms hang down at the subject's side and the pressure of the clipers is increased until the resistance of the bone is appreciably felt.

(9) Hips. The width of hips is measured in a similar manner to that of the shoulders with the large sliding calipers, using the widest part over the trochanters for the two terminal points.

(10) Face. The width of the face is taken with the spreading calipers at the greatest bizygomatic distance.

C. Diameter

The methods adopted here are those of Hrdlicka (406)

(11) Head (anterior-posterior)

"The maximum glabello-occipital diameter of the vault."

Instrument: The spreading compass or calipers (compas d'epaisseur, Broca or Hrdlicka).

"Landmarks: Anteriorly -- the most prominent point of the glabella; posteriorly -- the most prominent point of the occiput as shown by the maximum determinable spread of the branches of the compass (Intern. Agr.)"

"Method: According to older methods (see Bertillion, Martin), the end part of each branch of the instrument was held in one hand, as in measuring the face. For measurement of the head this is somewhat clumsy. A better method is to hold the compass so that its butt (or joint) rests on the hypothenar eminence of the hand, the two proximal parts of the branches reposing respectively on the ball of the medius and on the second joint of the forefinger, while the thumb holds the instrument to the hand. The observer applies the thumb and middle finger of his left hand, in contact, to just below the glabella, places the free end of the left branch of the compass on these fingers so that the point touches the glabella, and applies the left forefinger over the end. This gives a ball-and-socket arrangement which enables the measurer to hold the point of the left branch of his compass steadily over the glabella without fear of displacement. This branch of the instrument needs no further attention. The right hand is now moved around the proximal part of the compass, so that the two branches rest on the ball of the fourth and on the second joint of the middle finger and are held and controlled by the ball of the thumb and the ball of the forefinger. This hold permits not only an easy handling of the instrument with perfect control, but affords also a great facility for regulating the pressure. The free end of the right branch is then applied over and somewhat to one side of the median line of the most prominent part of the occiput, and is moved up and down in saw-tooth fashion from side to side of the occiput until the maximum length is encountered. The eyes watch only the scale. The ease of manipulating the instrument when handled in this manner is very gratifying."

(12) Head (transverse)

"The greatest transverse diameter in horizontal plane which can be found on the vault by the spreading compass (compas d'epaisseur, Broca or Hrdlicka.)"

"Landmarks: Determined solely by the maximum breadth of the skull above the supra-mastoid and zygomatic crests (Intern. Agr.).

"Method: The instrument is held as in first position for measuring the length, and this position is retained. The left hand is placed lightly on the top of the head of the subject, assisting in bringing the latter into the convenient position for taking the measurement; the instrument is applied horizontally somewhat above what appears to be the maximum breadth, and is moved in a zigzag way antero-posteriorly, descending and again ascending by zigzags, until the maximum breadth is found. The eyes watch only the scale. It is necessary to repeat the movements in an ascending and possibly once more in a descending direction, until the observer is positive that the maximum breadth has been ascertained."

(13) Head (height)

"The height from the middle of the line connecting the floor of the auditory canals to bregma."

Instrument: The spreading compass of Hrdlicka.

The methods adopted here are those of Hrdlicka.

"Method: The instrument is held by the right hand just below the joint. The head of the subject being steadied by the left hand, one branch of the instrument is gently introduced into the left ear as far as the guard permits, and the same is followed with the right ear. The compass is then slightly raised to assure penetration as far as the guards allow, is taken hold of a short distance above the scale by the left hand, allowed to sag down by its own weight and held in position. The ulnar side of the hand that holds the compass should for greater steadiness rest on the head of the subject behind the instrument. The scale of the compass is now brought as near as possible over the bregma, The spread of the branches of the compass is noted on the scale, the distance from bregma to lowest part of the scale is carefully ascertained by the rod of the sliding compass, and the operation is completed. All that is now necessary is to read off on a previously prepared scale the total height from the base line of the points of the compass to the lowest part of the scale of the same at the spread observed in the subject at hand, and to deduct from this the distance between the bregma and the scale. Special care must be exercised that neither of the branches, particularly that in the right ear, slips out of the meatus.

"This method is readily learned and causes the minimum of inconvenience to the subject (particularly if the points of the instruments are warmed in water or by the breath of the observer before introduction), and with due care it gives results which vary within less than 3 mm. The time required is scarcely more than the average time for ascertaining the head length. The external portions of the floor of the meatus, while not as perfect landmarks as could be desired, give with this method and instrument, in the writer's experience, results that are more satisfactory than those obtained by any other method or instrument so far devised for taking this important measurement of the head. The preference of bregma to the vertex for the superior 'point de repere', is in accordance with the Geneva Agreement, which stipulates two heights of the vault and both to the bregma."

(14) Chest (width)

The methods adopted here are those of Hrdlicka (406)

"Transverse diameter: Subject stands in natural, easy, erect position. The forearms are flexed at about right angles, and the arms are lifted forward and upward to about 30 degrees from the body. They are directed to be held limp without any tension, and the examiner satisfies himself that there is

no tension by lightly taking hold of the forearms and moving the arms slightly up and down. The object of the position is on the one hand to relax all the thoracic muscles, and on the other to permit the application of the instrument. The same position in every respect is preserved for the antero-posterior diameter.

"The large compass is now applied to the chest in such a way that its rod lies directly over the nipples (or corresponding line in women), the fixed branch is pressed against the thorax until it meets with the resistance of the ribs, and the right branch is applied repeatedly to the opposite side of the thorax, with equal pressure, during inspiration and expiration until the medium between the two can be arrived at. It is the medium which is recorded. The instrument is held so that its plane is at right angles to the vertical plane of axis of the thorax.

(15) Chest (depth)

The antero-posterior diameter is taken so that the fixed branch of the compass is applied to the nipple line, the rod of the instrument to the ribs on the left side, and the movable branch to the posterior part of the thorax, the instrument being held again at right angle to the vertical axis of the chest. Here also we take repeated measurements until the medium between normal inspiration and expiration is ascertained, and this is recorded."

D. Circumference

(16) Head. The circumference of the head is taken at the greatest distance over the frontal and occipital processes, the tension of the tape being regulated by practice or by the observation of the spring indicator on the tape.

(17) Chest. The circumference of the chest is taken, with or without clothing, at the nipple line for boys and at corresponding height for girls.

E. Weight

(18) Body Weight. The weight is taken with or without clothing. When clothing is included, the shoes and coats are removed. Clothing for children below 12 years of age weighs on an average .75 kgs. and for children over 12 years of age on an average 1.1 kgs.

(19) Lung Capacity Minus Residual Air. The measurement has been taken in the usual manner, with conditions standardized as far as possible, using the wet spirometer, which gives the volume of lung capacity minus the residual air. Mr. A. W. L. Bray, who began his work at the Station on January 1st, 1921, as a Research Associate in Child Welfare, will aim to standardize new instruments and technique. Waldenburg's pneumatometer is being tested out and various other methods of measuring respiratory capacity.

G. Strength

(20-23) Here again the generally used methods for the hand dynamometers have been used. The writer has found the "Martin Method" (Walter Reed General Hospital Monograph I, Washington, D. C., pp. 11 ff.) a promising one, and the

Kellogg method used at Battle Creek is also being tried out.

H. Indices

(24-29) (For a theoretical discussion of indices of growth, see Chapter VI. The sitting-standing index is determined by dividing the sitting height by the standing height; the cephalic index by finding the ratio of the width of the head to the length; the chest index by dividing the depth of the chest by the width; the vital index by dividing the breathing capacity by the height; the weight-height index by dividing the weight in kilograms by the height in centimeters or by the square or cube of the height.

I. Cranial Capacity

For the present the Lee and Pearson (468) formula No. 14 is being used.
It is

Male. Brain cc. = .000337 (L-11mm.) (B-11mm.) (H-11mm.) + 406.01.

Female. Brain cc. = .0004 (L-11mm.) (B-11mm.) (H-11 mm.) + 206.6

1. *Chrysomelidae*

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10. Conclusions

This study of 4800 consecutive measurements in weight on 200 white babies and 200 colored babies approximating normal development shows that for this group:

I. For these infants at birth, the boys and girls weigh approximately the same. The white boys gain in weight more rapidly than the girls and are 454 grams to 681 grams heavier from the second month to the thirteenth month. The colored boys are from 284 to 567 grams heavier than the girls between the fourth and ninth months, but lose this advantage by the end of the year.

II. For this group of infants the colored babies, both boys and girls, weigh on an average 227 grams less than the white babies. This difference becomes greater until at the end of one year the colored babies weigh from 454 to 907 grams less than the white babies, both boys and girls.

III. As a rule, the babies that are relatively heavy at birth are heavy at the age of four months, and those that are light at birth remain relatively light. On an average, these boys double their birth weight at the end of the seventh month, and the girls at the end of the eighth month.

IV. The coefficients of correlation between weight at birth and weight in the 14 to 15 weeks period are, for white girls + .537, for white boys + .263; for colored girls + .649, and for colored boys + .584. This coefficient decreases as we approach the 34 to 35 week periods, until with the end of the year there is no positive correlation for this group of children. It is not possible to prophesy with a high degree of assurance that if one of these children is heavy at birth, he or she will be relatively heavy at the end of the first year.

V. From 60 to 70 per cent of the babies who are above the average weight at the beginning of the first year are still above average at the end of the year and vice versa, with considerable individual variation within these ranges. They vary a great deal as to the amount they are above or below during this period.

VI. These artificially fed babies as a rule weigh less than the breast fed babies; this is particularly noticeable during the first few months.

VII. The individual growth curves during the first year show a wide range of individual and racial differences at all weekly periods.

11. Supplementary Data Based on Group of Infants Studied

1. The most frequent infant disease recorded for these children is diarrhea, but this has no serious noticeable effect on growth if checked soon and no other complications set in.

2. Bronchitis, constipation, indigestion, otitis media, coughs, and colds, retard growth if allowed to continue for several weeks.

3. Pneumonia is a serious disease from the standpoint of growth for these infants. It occurs more frequently with the colored children than with the white. There are seven cases of pneumonia reported for the white babies and 16 for the colored babies.

4. The white girls show 50 per cent more illness recorded than the white boys.

5. For this group of children, digestive disturbances are more important in interfering with growth than are respiratory disturbances.

CHAPTER V

PHYSICAL GROWTH OF SCHOOL CHILDREN

* * * *

Conclusions (Set 1 and Set 2)

1. Height

I. For boys and girls from six to 18 years of age there is a slight adolescent acceleration in height, sitting height, weight, breathing capacity and the strength traits which appears earlier for girls than for boys and earlier for tall girls or boys than for those below the norms.

II. A series of individual growth curves of varying heights approximates in form a series of concentric arcs of varying sizes where a chronological point in the lower arcs is reached later than a corresponding point in the upper arcs.

III. As a rule tall boys and tall girls reach their periods of maximum adolescent stature earlier than do short ones.

IV. If the increments of growth in stature before adolescence are relatively uniform (i. e. represented by a straight line on the charts) this uniformity of increase tends to persist throughout adolescence. If there is retardation before adolescence the tendency is to show a rapid acceleration during adolescence, as a compensating factor.

V. With boys and girls the stature curves show a railroad appearance with relatively little crossing but a tendency to fan out at adolescence.

VI. Tall children at any age remain relatively tall under normal conditions. Growth in height is so comparatively uniform for each individual that the growth curve enables one to prophesy with a high degree of accuracy how tall a young child will be at subsequent years.

VII. Growth in height is affected by the formation and removal of adenoids.

VIII. Prolonged disease history retards normal growth in stature.

2. Weight

I. Growth curves in weight from seven to 17 years of age tend toward concavity; those in height toward convexity.

II. There is more individual variation in growth in weight than in growth in height.

III. Pre-adolescent acceleration in growth of weight precedes as a rule the pre-adolescent acceleration in growth in height.

IV. The pre-adolescent acceleration in growth in weight is earlier, chronologically, for the tall boys or girls than for the short ones.

V. Growth in weight is affected by disease history and the growth and removal of adenoids.

3. Sitting Height

I. The trend and distribution of individual curves in sitting height are almost identical with the trend and distribution of the standing height curves for boys and for girls, more particularly for boys.

II. The conclusions outlined on page 92 for individual growth in stature apply in general for individual growth in sitting height.

III. Growth in sitting height is affected by disease and adenoids, as in the case of standing height.

IV. Sitting height standards are more satisfactory from an anthropometric point of view than those for standing height.

4. Chest Girth

I. Chest girth for girls is relatively less than for boys during the pre-adolescent period.

II. Cessation in growth of chest girth occurs earlier for girls than for boys.

III. Development of chest girth does not parallel growth in stature, as do the other traits previously mentioned.

5. Breathing Capacity

I. Measurements of growth in breathing capacity involve a mental factor which differentiates this measurement from those of height, weight, sitting height and chest girth.

II. Individual breathing capacity curves, like those for weight, tend toward concavity, which is more marked in the boys' curves than in the girls'.

III. There are marked individual variations in the breathing capacity curves.

IV. Larger and taller children as a rule have greater breathing capacity than smaller ones.

V. Girls show inferior development in breathing capacity to boys.

VI. Girls reach their periods of cessation of growth before boys.

1. The first part of the report, which is the most important, is the one that deals with the general situation of the country.

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18. The eighteenth part of the report, which is the most important, is the one that deals with the general situation of the country.

VII. Taller, heavier boys and girls as a rule have their accelerated periods of growth in breathing capacity at an earlier period than do those below the norms in height and weight.

VII. Retarded development in stature and weight is paralleled by retarded development in breathing capacity.

6. Strength of Arms and Upper Back

I. Individual strength curves for arms and upper back are similar in irregularity to the breathing capacity curves.

II. As in the breathing capacity curves, the element of voluntary effort plays an important role in evaluating the development of strength.

III. Girls are inferior to boys in all strength tests, girls showing, after 15 years of age, little increase, and frequently a decrease in strength.

IV. The right arm as a rule for both boys and girls is stronger than the left, but the difference is not so marked as has usually been assumed.

V. In the distribution of strength curves, there is more overlapping, with marked fluctuations in increments of improvement or regression in individual strength curves than in the case in curves of height, weight, breathing capacity, sitting height and chest girth.

VI. The observed correlation between individual stature and strength curves is not so evident as in the other traits previously outlined.

VII. Development in strength of right arm, left arm and upper back is materially affected by prolonged disease history.

CHAPTER VI

CORRELATIONS IN PHYSICAL GROWTH OF SCHOOL CHILDREN

* * * *

3. Conclusions

I. Of the nineteen relationships between measurements of total growth from the years seven to 17 (in height, weight, and breathing capacity) and the measurements of growth of parts (in sitting height, girth of chest, strength of right arm, left arm and upper back) the correlation coefficients are higher for boys than for girls. The only exception is the correlation between development in weight and girth of chest, where there is involved a distinct anatomical factor.

II. It will also be noted that boys not only grow very differently from girls, but that their development is decidedly more highly correlated in its varied aspects. There is a biological difference between the growth of boys and girls during these ages from seven to 17.

III. All coefficients are positive and tend to be highest during early adolescence and lowest at 17 years of age. The periods of irregular development for individual boys and girls are from seven to 10 years of age and during later adolescence. There is a wide range of individual differences among the boys, but a decidedly less constant and unified development among the girls. The analysis and interpretation of the growth of each series of inter-related physical traits is shown by the tabulated and graphic distribution, and the correlation coefficients give a new insight into the development of the human organism during the plastic period from childhood through adolescence.

IV. Because boys and girls show a wider range of individual distribution and because boys and girls differ more in growth from each other at the adolescent period, it has been concluded that this is a period of irregular individual growth. The consecutive intercorrelations of the various physical traits for both sexes show this to be unfounded. The coefficients of correlation are highest during early adolescence and begin to decrease after 14 years of age.

V. The correlation coefficients expressing on the average the physical development relationship for the period from seven to 17 years of age for boys and girls rank in the following order, from highest to lowest:

Boys Rank	Girls Rank	
1	2	Height-sitting height
2	1	Weight-girth of chest
3	3	Strength of right arm-strength of left arm
4	6	Height-weight
5	7	Weight-sitting height
6	4	Height-breathing capacity
7	5	Breathing capacity-sitting height
8	9	Weight-breathing capacity

9	10	Breathing capacity-girth of chest
10	11	Weight-strength of right arm
11	13	Height-girth of chest
12	15	Weight-strength of left arm
13	16	Weight-strength of upper back
14	17	Breathing capacity-strength of right arm
15	8	Height-strength of right arm
16	19	Breathing capacity-strength of left arm
17	18	Breathing capacity-strength of upper back
18	14	Height-strength of left arm
19	12	Height-strength of upper back

VI. College girls who have had the benefit of physical training show an increase in correlated development in height and breathing capacity from the freshman to the senior year. This is due in part probably to the systematic training and athletics in which these girls participated. The coefficients are lower for college girls than for school girls.

VII. Pearson found "that as far as the correlation between weight and height is concerned, men start with a scarcely sensible advantage over women as infants and conclude as adults with an immensely less correlation than women, among whom it appears to have slightly increased, or at any rate not to have decreased." These results of consecutive measurements for eight years or more give:

Coefficients for seven year old boys + .872 and girls + .559.
Coefficient for 17 year old boys + .680 and girls + .547.

The specific conclusions derived from the partial correlations are outlined on pages 137 to 139. The general conclusions are:

VIII. Growth in weight for boys and girls has little effect on growth in height and sitting height, but does materially affect the growth of girth of chest, and also the development of strength, especially for boys.

IX. Growth in height for boys and girls has little effect on the growth of circumference of chest, but does materially affect growth in weight, sitting height and development of strength, especially for the girls.

X. Growth in breathing capacity has a decided effect on the growth of the other traits except sitting height.

4. Practical Applications

It is not the purpose of this section of the scientific Study to attempt to indicate many practical applications. These will follow in abundance after the fundamental principles of growth have been formulated and studied, but a few obvious educational corollaries may be cited from the preceding basic conclusions;

(1) Since girls and boys show inherent sex differences in total and partial growth, and in the relationships of these at all ages from seven to 18, girls should have different forms of physical training and different forms of directed play from boys;

(2) A careful analytic study of the periods of growth of boys and girls should precede any provisions for their physical education, and the results of such study will throw light on their development in general motor coordination, and in the mental traits which accompany, directly and indirectly, rhythmic or irregular physical development;

(3) There should be a graduated series of adjustable school desks in accordance with the general laws of physical development and individual differences in boys and girls.

VARIABILITY IN PHYSICAL GROWTH OF SCHOOL CHILDREN

(2) Conclusions

I. For height boys have a greater variability than girls at all ages between seven and 17, except at 12 and 17; at 13 they are the same. Boys fluctuate more in variability in height than girls.

II. For weight boys have greater variability except at the ages of nine to 13, inclusive, and at 16 and 17. Girls also fluctuate more in variability in weight than boys.

III. For breathing capacity the boys are more variable than the girls at all ages except seven, eight and 12.

IV. The variability for sitting height is greater for boys at all ages except at eight, 12 and 13.

V. For chest girth, the variability is the same as for weight, the boys being more variable except from nine to 13, inclusive, and at 16 and 17.

VI. For strength of right arm, the variation for boys is greater for all ages except seven, 10 and 11, and the more variable ages for girls for the left arm are 11 and 12.

VII. The variability in strength of upper back for boys is greater than for girls, except at the ages of seven and nine.

VIII. These results show boys to be more variable in height and weight than Pearson (576) found and also Bowditch (113), who, in turn, found them more variable than did Boas and Wissler (100).

G. Group II.

(1) Data. In order to find the coefficient of variability for the same children for consecutive years, a group of 115 boys and girls whose measurements were taken at six years of age and consecutively for six years later, was used, and another group of 138 boys and girls of nine or 10 years

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of age, with consecutive measurements for six years. The results in Table XXVII show the following:

(2) Conclusions

- I. Boys are more variable than girls at six years of age and six years later, also at nine or 10 and six years later.
- II. For weight the girls are more variable at six years of age and six years later; at nine or 10, the variability is approximately the same, and six years later boys are more variable.
- III. For breathing capacity boys are more variable at six years of age and six years later, and also at nine or 10 and six years later.
- IV. For strength of right arm boys are more variable at six years of age and six years later, and also at nine or 10 and six years later.
- V. Pearson also states that "both sexes lose not only variability, but correlations as they grow older." This statement is too general.
- VI. Many of the coefficients of correlations increase with age, practically all increasing from nine or 10 to 14 years of age, the same holding true for the coefficients of variability for height, weight, and breathing capacity at 13 or 14 for boys and for girls. In the strength tests, the variations decrease in general with age, with a rise at 15 years of age.
- VII. For the ages from nine or 10 and six years later, there is a decrease in the coefficient of variation for height and weight for boys and girls.
- VIII. In breathing capacity there is an increase in variability for both boys and girls for these ages.
- IX. In strength of right arm there is an increase in variability for boys and a decrease for girls for these ages.

C. Group III.

(1) Data. For the group of 80 college girls whose measurements were followed throughout the four years of college, the results show:

(2) Conclusions

- I. The results for the eighty college girls from 17 to 21 years of age show a lower coefficient of variation than for girls from seven to 17 years of age, with a slight drop from the freshman year to the senior year.
- II. The coefficient of variation for college girls for weight is lower than for the ages nine to 14 years, but higher than for 15, 16 and 17 years of age.

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III. In breathing capacity there is a gradual decrease in the coefficient of variation for the college girls from the freshman to the senior year, and a lower coefficient than for any of the other ages previous to 17 years.

IV. For strength of right arm, the college girls show in general a coefficient of variability similar to the previous group after 13 years of age, the sophomore college girls being almost as high as the seven year old girls of the previous group.

8. Growth Norms for Group Used for Correlations

a. Data. In order to compare the group of Horace Mann boys and girls whose correlations have been expressed in Tables XVI and XVII with larger groups and with those from other schools, the averages of the individual for the eight traits used in the 19 series of correlations from seven to 18 years of age are expressed in Table XXIX.

The yearly records include 10,560 yearly measurements based on semi-annual examinations for eight years or more on the same individuals, or approximately 60,000 measurements.

Standard Weight-Height-Age and Height-Breathing Capacity-Age Tables for all of the normal standard children included in this Study have been worked out and will be published in the form of a separate Table and Practical Score Card.

b. Conclusions

These results are typical for height, weight and breathing capacity and almost identical when compared with the previous norms for larger groups in the 1914 Bulletin and the new ones on page 152. The means for the other five traits are also very similar to the norms in the Supplement. It will be noted that:

- I. Girls are taller than the boys from 10 to 14 years of age.
- II. Girls are heavier than boys from nine to 16 years of age.
- III. Girls are inferior to boys in breathing capacity for all ages.
- IV. Girls are superior to boys in sitting height from 10 to 16 years of age.
- V. Girls are superior to boys in chest girth from 12 to 15 years of age.
- VI. Girls are inferior to boys in strength of right and left arms and upper back at all ages.
- VII. For normal children between seven and 17 years of age, these results may be considered as normal average standards.

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c. Applications. As normal standards these averages, their deviations, the yearly increments, the indices and the annual percents of gain may be used for evaluating the growth of groups of American children within these age limits. The norms, which are among the highest in the world, show what school medical inspection, physical training and directed play can do for children; for many of these boys and girls were sickly or under-nourished when small and several are Hebrews, who are racially of small stature and small features.

9. Mean Deviations in Growth of Correlation Groups

a. Data. In studying the comparative growth of a number of individuals for consecutive chronological ages, the mean deviations are important on account of showing the distribution of individuals within the groups. The mean deviations are shown in Table XXX.

b. Conclusions.

I. The girls show higher mean variations than the boys at 12 and 13 years of age in height, lower at the other ages between seven and 18.

II. The mean variations for girls in weight and sitting height are higher for all ages from eight to 18 years.

III. Girls also have a higher mean variation in chest girth from nine to 17 years of age.

IV. Girls have a lower mean variation for all ages in breathing capacity.

V. Girls have lower mean variations in strength of right arm, left arm and upper back for all ages from seven to 18 years.

VI. In every trait except in weight and chest girth the boys show a wider range of distribution for these ages.

VII. The greatest mean variations for both boys and girls are during the characteristic adolescent ages for each; the smallest are during the earlier periods from seven years to nine years of age.

10. Yearly Increments of Growth of Group

a. Data. The actual annual increments of yearly growth are significant for this group as shown in Table XXXI. "A study of the individual measurements in height reveals different correlations in growth for boys and girls above the median from those below. That is, the rhythms of fluctuations of growth for tall children differ materially from those for short children. This is demonstrated by the norms found, which serve in this connection as a temporary expedient for estimating the relative heights of the children and as a means for dividing them into two general groups, those lying on and above the median and those lying below the median. There are some who cross the median, and others whose curves fluctuate toward or from the median. Those lying above the median height begin and end their periods of acceleration and arrest earlier than those below the median." For increment data see former

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monograph (27), pages 30 to 31. For new norms for tall and short girls see table XXXVI pages 165 and 166.

"As will be noted, the results give the greatest absolute increment and the greatest average deviations during the adolescent period, beginning at 12 years of age for boys above the median height and beginning at $10\frac{1}{2}$ years for girls above the median. This marked acceleration continues until $15\frac{1}{2}$ for boys and until 13 for girls. For those below the median height the greatest average acceleration begins at 14 years for boys, and at $11\frac{1}{2}$ years for girls, and continues, for the boys, until $17\frac{1}{2}$ and for the girls until $15\frac{1}{2}$.

"The rhythms and fluctuations of growth in height for the children above the median show that these boys and girls mature in physiological growth earlier than those below the median, since their periods of acceleration and arrest begin earlier and end earlier. There are individual measurements lying on either side of these medians, arranged in all probability in a normal distribution from the tallest to the shortest for each chronological age. If this is the case, as the individual curves will show, we are justified in making averages or medians only when the average or norm is based on the physiological age instead of the chronological age. A new and very important educational problem is evoked here: How may we formulate a measuring scale for determining the physiological age of the child? A careful study of individual growth curves, based on consecutive measurements, it is hoped, will help to answer this question." (27).

b. Conclusions.

I. In yearly increments of growth there are not only sex differences, but a wide range of differences for each trait at various ages.

II. The increments are higher in the case of girls than of boys as follows: from nine to 13 years of age for weight; from 11 to 13 years of age for breathing capacity; from eight to 13 years of age for sitting height; from eight to 13 years of age for chest girth; from eight to 13 years of age for strength of left arm. They are inferior at all other ages for all traits and for these ages (eight to 13) for strength of right arm and upper back.

11. Yearly Per Cent of Gain from Seven to 14 Years of Age

This table is significant in that it shows the annual increase in increment in growth for the eight physical traits under consideration. The yearly gains in per cent can be best gleaned from Table XXXII. It should be noted that

I. For growth in height the yearly increment of per cent is very uniform for boys from seven to 16, with a short rise from 12 to 13 years of age; for girls from seven to 13 the yearly increment of per cent is very uniform, with the rise from 12 to 13 and a cessation after this age.

II. For growth in weight there is a higher percentage increment for all ages up to 13 years for boys, with more irregularity than for the previous traits outlined, and with the peak of increase between 12 and 13.

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III. For breathing capacity the percentage increase is a little higher and more irregular than for height. The girls are higher than the boys until 13 years with no definite peak period.

IV. The lowest annual increase in per cent is in sitting height for boys and girls, and the highest in strength of upper back. This is also shown graphically in the profile charts, pages 111, 112, 113 and 114. For sitting height the annual per cent of gain is lower for the boys than for girls until 12 years of age.

V. Growth in chest girth, which is also lower for boys until 14 years of age, is also small and more variable than for sitting height.

VI. and VII. For strength of the arms the annual increase is a little higher than for the previous traits, with variations for the two arms and for boys and girls, the boys increasing more on the average than the girls.

VIII. For upper back there is a greater annual increase than for other traits, but there is so much variation that no definite age stands out prominently, the boys growing more on the average than the girls.

12. Indices of Growth of Group in Table XXIX.

a. Data. As previously emphasized, the relationship between the growth of two physical traits which may be expressed as an index, is more significant than is the growth of either. The importance of the index or coefficient of robustness (the weight-height coefficient) is outlined in Part IV and this index should form the normal standard of growth in place of either height or weight. Table XXXIII gives the average indices of all ages and for each sex. There is little or no apparent difference, as a rule, between the tall boys and the short boys, except that the tall individuals have high indices early. This clearly substantiates the important conclusions previously stated that the development of any normal physiological change in the traits measured occurs earlier for tall children. For data see Figs. 1 to 29 and pages 30 to 71 in the earlier monograph (27).

That the weight-height indices vary with different nationalities can be demonstrated by selecting weight and height tables from Part V. Take for example Erismann, Baldwin, Pagliani, Bobbitt and Misawa. From eight to 15 years of age the indices for the Russians increase for the boys from .201 to .361; for the Americans from .196 to .306; for the Italians from .175 to .275; for the Filipinos from .174 to .268; and for the Japaneses from .168 to .265. That is, the Russians and Americans are heavier for their stature than are the other nationalities represented.

b. Conclusions

(1) Weight-Height Index

I. The weight-height index is the most practical criterion of normal growth in robustness, and, other conditions being normal, in general nutrition.

II. The weight-height indices increase from six to 18 years of age on the average 100 per cent, which shows that weight increases more proportionately than height.

III. A well-developed tall or short child approaches within 15 per cent of the weight-height index for the chronological age to which the child's height corresponds.

IV. For tall boys and tall girls the coefficient for the weight-height is in advance chronologically of that for the mean or average and the reverse holds true for short children. The tall heavy children are older physically.

V. In interpreting and evaluating the seven series of indices for each age for each sex, it should be noted that the weight-height indices for girls are higher at all ages, which means the girls are proportionally heavier for their height than boys.

(2) Vital-Height Index

I. The vital-height index is a good criterion of the respiratory height relationship.

II. The vital-height index more than doubles for boys during the ages from six to 18 years and nearly doubles for girls, which shows that in growth in breathing capacity boys increase proportionately more than in growth in height.

III. The vital-height index is higher for the boys than for the girls at all ages, which shows that boys have greater breathing capacity for their heights than girls.

IV. A well developed tall or short child should approach within 15 per cent of the vital-height index for the chronological age to which the child's height corresponds.

V. For tall boys and tall girls the coefficient for the vital-height is in advance chronologically of that for the mean or average and the reverse holds true for short children.

~~(3) Sitting-Height Index~~

(3) Sitting Height-Height Index

I. The sitting height indices for boys and girls show on the average a slight decrease from six to 16 years of age, and for boys from six to 13 years of age, which shows that standing height is increasing more proportionately at these ages than height-sitting.

II. Girls maintain a relatively higher sitting height-height relationship than boys.

(4) Chest Girth-Height Index

I. Chest girth-height indices change little from seven to 13 years of age, with a slight drop for ages from 11 to 15.

II. Girls have a slightly higher index than boys. After 13 the index is considerably higher for girls.

(5) Strength of Right Arm-Height Index

I. The strength of right arm-height indices increase on the average steadily from six to 18 years to more than 100 per cent for boys and approximately 100 per cent for girls, which shows that the strength of the right arm increases more proportionately than the stature.

II. In the strength-height relationships for right arm the boys are invariably superior.

(6) Strength of Left Arm-Height Index

I. The strength of left arm-height indices increase on the average steadily from six to 18 years to more than 100 per cent for boys and approximately 100 per cent for girls, which shows that the strength of the left arm increases more proportionately than the stature.

II. The indices for the left arm are uniformly lower with this group of children than those for the right.

III. In the strength-height relationships for left arm the boys are invariably superior.

(7) Strength of Upper Back-Height Index

I. The indices for growth of strength in upper back increase more from six to 18 than any of the other indices. For the boys this increase is nearly 300 per cent, for the girls about 250 per cent.

II. Boys increase most during the ages from 14 to 18 and girls increase least after 15 years of age.

III. In the strength-height relationships for upper back the boys are invariably superior.

13. Per Cent of Increase Between Seven, 12, and
17 Years of Age

a. Data. What per cent of a boy's or girl's growth at 17 years of age has he or she reached at seven years of age, and at 12 years of age? Do boys and girls grow more between seven and 12 years of age or between 12 and 17 years of age? These are very important questions from many standpoints for individuals and the problems are analyzed further by a study of individual growth curves. The averages as given in Table XXXIV and XXXV will answer the question in a general way and will show the group tendencies.

b. Conclusions

I. Girls have completed at seven years of age on the average in each of the eight physical traits: height, weight, breathing capacity, sitting height, girth of chest, strength of right arm, strength of left arm, and strength of upper back, a higher per cent of their final development (at 17) than have boys.

Table XXXIV

PER CENT OF INCREASE BETWEEN SEVEN, 12 AND 17 YEARS OF AGE

Traits		At 12 yrs.	At 17 yrs.	Bet. 7 & 12	Bet. 12 & 17
Height	Boys	119%	142%	19%	23%
	Girls	121	135	21	14
Weight	Boys	155	259	55	104
	Girls	167	245	67	78
Breathing Capacity	Boys	168	314	68	146
	Girls	174	254	74	80
Sitting Height	Boys	113	134	13	21
	Girls	115	130	16	15
Girth of Chest	Boys	116	146	16	30
	Girls	121	141	21	20
Strength of Right Arm	Boys	189	360	89	171
	Girls	196	287	96	91
Strength of Left Arm	Boys	182	339	82	157
	Girls	207	297	107	90
Strength of Upper Back	Boys	236	502	136	266
	Girls	231	354	131	123

Table XXXV

PER CENT OF FINAL GROWTH AT 17 YEARS OF AGE THAT HAS BEEN
ATTAINED AT SEVEN AND 12 YEARS OF AGE

Traits		At 7 yrs.	At 12 yrs.	Bet. 7 & 12 yrs.	Bet. 12 & 17 yrs.
Height	Boys	70.3%	83.8%	13.5%	16.2%
	Girls	74.2	90.	15.8	10.
Weight	Boys	38.7	60.1	21.4	39.9
	Girls	40.9	68.2	27.3	31.8
Breathing Capacity	Boys	31.9	53.7	21.8	46.3
	Girls	39.3	68.3	29.	31.7
Sitting Height	Boys	74.5	84.5	10.	15.5
	Girls	77.	88.6	11.6	11.4
Girth of Chest	Boys	68.6	79.7	11.1	20.3
	Girls	70.8	85.5	14.7	14.5
Strength of Right Arm	Boys	27.8	52.5	27.4	47.5
	Girls	34.9	68.4	33.5	31.6
Strength of Left Arm	Boys	29.5	53.7	24.2	46.3
	Girls	33.7	69.9	36.2	30.1
Strength of Uppers Back	Boys	19.9	47.1	27.2	52.9
	Girls	28.3	65.3	37.	34.7
			7 yrs.	12 yrs.	17 yrs.
Sitting Height	Boys		54.3%	51.6%	51.2%
to					
Standing Height	Girls		54.7	51.9	52.8

II. Girls gain between seven and 12 years of age a greater percent of their final growth (at 17) than do boys, in all of the eight traits: height, weight, breathing capacity, sitting height, girth of chest, strength of right arm, strength of left arm, and strength of upper back.

III. From 12 to 17 years of age, girls gain a higher per cent than boys in sitting height, chest girth, strength of right arm, left arm and upper back.

IV. Boys and girls both gain a higher per cent from 12 to 17 years of age in the other traits of weight and breathing capacity.

V. The girls at seven years of age have reached a stage of development considerably in advance of that of boys, and girls continue this lead in all phases of growth, so that a 12 year old girl is as far advanced toward her final growth at 17 as a 14 year old boy.

VI. The direct per cent of sitting height to standing height at seven, 12, and 17 is almost identical for boys and girls. The ratio is approximately 1-2 being slightly below this at seven years of age.

VII. Girls grow more proportionally than boys from seven to 12 years of age in height, weight, breathing capacity, sitting height, girth of chest, strength of right arm, strength of left arm. Boys gain slightly more in strength of upper back.

VIII. Boys grow more proportionally than girls from 12 to 17 years of age in height, weight, breathing capacity, sitting height, girth of chest, strength of right arm, strength of left arm and strength of upper back.

14. Norms for Tall and Short Girls

These norms for girls above or below median height show that on an average the tall girls surpass the short girls in all of the eight physical traits outlined. They also show that tall girls grow differently than short girls. These norms supplement those on page 152 but include more cases.

CHAPTER VII

ANATOMICAL AGE

1. The Anatomical Development of Boys and Girls

Two closely related ages which characterize a child's development quite as much as its chronological age in years, months and days, but are less understood, less commonly used, and therefore less familiar to parents and teachers, are the anatomical and physiological age. These denote the physical, or anatomical, growth and the accompanying stages of physical maturation of the individual as indicated by growth of bones, eruption of teeth, color of eyes, metabolism, marked functional changes in sex organs, changes of voice and many other phases of physiological development not so apparent to the casual observer.

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Children of the same chronological age may vary greatly in their anatomical and physiological development. Since physical growth in the larger sense conditions all other aspects of development, it is essential that these ages be discussed in detail. Few scientists have attempted to differentiate between these two ages, but this is essential if a careful study is to be made of the development of childhood. An analysis of the anatomical growth of the carpal bones (the wrist) will be made, a diagnosis of the physiological age at adolescence will be outlined empirically, and some specific correlations between the two ages with applications will follow.

a. Roentgenograms as Criteria of Anatomical Age. In order to throw more light on the previous data on physical growth, the writer made a comparative study of the carpal bones of a group of boys between the ages of 11 and 13 and a group of girls between the ages of 10 and 13, the growth being followed for three years. These children from the seventh school grade of the University of Iowa Junior High School, are as nearly as could be determined in a preliminary way, normal children from good, representative homes, with normal school progress, as indicated by school grades, school marks, and a series of mental examinations for the three consecutive years. The analyses give a good insight into the physical status of these young adolescents, since the ossification of the bones of the wrist is representative of the skeletal development in general.

The roentgenographs included in this investigation were taken in the Department of Roentgenology of the University College of Medicine by Dr. Bundy Allen. One series was taken in 1918 just before the writer was called into the U. S. Army, and another series on the same individuals after his return, and a third series in October, 1920. The roentgenograms were of the exact natural size and the two hands were placed in a uniform position as far as possible. The individual differences in the forms and positions of the carpal bones and the difficulty of differentiating between various stages as the cartilaginous tissue develops into osseous substance present distinct problems in determining the topographical area of the bones.

b. Method of Finding the Area of the Bones of the Wrist. At first attempts were made to measure the perimeter of the individual bones by means of a map tracer and protractors. This method was soon discarded and a method of tracing the outlines on millimeter cross section paper through an illuminated frosted glass plate was tried and also discarded. The tables in this section of the Study give the measurements as found by means of the planimeter with which the area of surfaces of irregular outline can be determined with accuracy. The accompanying photograph (12) shows the development at the beginning and at the end of the two year interval for one boy, No. 8376 (John). In 1918 the total exposed area of the seven bones was 1110 sq. mms. and just two years later, 1920, the total area was 1832 sq. mms. In this case there was marked growth in the area of each bone and in the total area also because of the appearance of the pisiform (116 sq. mms.) after the two year period.

All original X-ray photographs have been reduced in these cuts from natural size by means of a uniform scale which makes the photographs of this Study comparable.

Further examples of the differences in the development of the wrist bones at various ages are contained in a series of comparative observations on No. 8370 and No. 8376 for the year 1918 showing that in physical growth No. 8376 (John) is advanced, being both taller and heavier; in the anatomical development of the seven observable bones of the wrist No. 8376 has a larger projected surface area for bones separately and for all of the bones collectively. The same differences are observable in the photographs for 1920; in physiological development No. 8376 (John) was post-pubescent in 1918 and No. 8370 (Eldon) pre-pubescent; in chronological age No. 8376 (John) is six months younger than No. 8370 (Eldon). These data demonstrate that No. 8376 (John) is the older boy anatomically, although chronologically six months the younger.

c. Conclusions.

- I. The size and number of the carpal bones increase with age during childhood.
- II. The development of the two wrists varies with individuals, but on the average there is no difference.
- III. Girls at a given chronological age have a larger exposed surface area of the carpal bones of the wrist than have boys.
- IV. Another evidence of the accelerated anatomical development of girls over boys is shown in the presence and development of the pisiform bone, which appears earlier during the pre-adolescent age with girls than with boys.
- V. There is a high coefficient of correlation between height and area of the carpal bones (Boys + .879, Girls + .729) and also between weight and area of the carpal bones (Boys + .755, Girls + .766.)
- VI. Boys have a higher correlation than girls for height and area of carpal bones and about the same as girls for weight and area of the carpal bones.
- VII. The coefficient of variation of the carpal bones is higher for boys than for girls (Boys 29.94, Girls 12.695).

CHAPTER VIII

PHYSIOLOGICAL AGE

1. The Age Distribution of Pubescence of Boys and Physiological Maturation of Girls

The subjects of physiological and anatomical ages have been confused in the literature, because neither has been investigated empirically beyond a limited degree, although both are full of fertile problems of great significance in the study of individual development. The direct applications of the meaning of these ages to physical, mental, pedagogical, social and moral development have been recognized to a very limited extent.

There is a wide range to be found in the physiological differences between boys and girls of the same chronological age, as will be demonstrated by the data following. Some boys reach pubescence at 11 years of age, others not until 16 years of age; some girls reach this period of maturity at 10

years of age or earlier, others not until 16 or 17. Boys and girls who mature early in these functions may be considered physically older than those of later maturation.

a. Data for Boys. In order to determine the wide range of chronological ages that characterize the stages of physiological growth which are entered into at adolescence, the writer and one of his advanced students at Johns Hopkins University, Charles F. Pennington, checked very carefully some material that was gathered under the direction of Dr. William Burdick and Dr. Brown on the ages of pre-pubescence, pubescence, and post-pubescence in boys. (28) In Baltimore 3600 boys of a "motor" type of development, that is, those taking part in athletics, were examined. These data were supplemented by those from a group of 1317 boys from 14 counties of Maryland, making a total of 4917 boys. With these particular children the criterion was that of pubescent growth and pigmentation of fine hair, which characterizes a very brief period of time marking the change from asexual to sexual life, when the ability to procreate is established.

It is found that the pre-pubescent boys range from eight and one-half to 16 years of age in the group of country boys, and from nine and one-half to $17\frac{1}{2}$ for the city boys. The post-pubescent ages range from $11\frac{1}{2}$ to 24 for the country boys and $12\frac{1}{2}$ to 24 for the city boys. For the pubescent stages the country boys range from nine and one-half to $15\frac{1}{2}$, with the mode at $13\frac{1}{2}$, and the city boys from 10 to 18, with the mode at 14. The country boys reach this period earlier than the city boys. At no age are more than 53 per cent of the age group of the city boys pubescent or more than 40 per cent of the country boys.

A method is now being formulated and carried out by the writer with the University of Iowa Junior High School boys, which indicates that pubescence is but a rough and inadequate criterion of the secretion of the sperm cell.

b. Data for Girls. For the girls the criteria were the first menstrual flow, enlargement of the breasts, the appearance of sub-cutaneous fat, and axillary hair, as noted by the physician or nurse. Chart LV shows the age distribution in terms of per cent of 47 girls from the University of Iowa Elementary and High School who had their first period of menstruation between the ages of 10 and 17 years; and a similar distribution for 151 Horace Mann school girls, 56 University of Chicago Elementary and High School girls and 134 Baltimore County girls from the Baltimore Athletic League. These data are accurate and represent typical groups of normal girls from the middle and upper class homes.

These data furnish satisfactory criteria for specific purposes, but other types of criteria are being worked out at the present time by the writer.

c. Conclusions

- I. These data show that among children who are best developed from a physical point of view, there is no fixed age for physiological development as evidenced by the advent of pubescence or first menstruation. Adolescence does not begin at the same chronological age for all normal boys or for all normal girls, physiologically

TABLE XLI

PERCENTAGE DISTRIBUTION OF PHYSIOLOGICAL MATURATION -- GIRLS

1. University of Iowa Elementary and High School Girls

Ages	Cases	Per Cent	Median
11	4	8.51	13 years
12	9	19.14	7 months
13	18	38.29	
14	10	21.27	
15	6	12.73	
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	47	99.97	

2. Horace Mann Elementary and High School Girls

Ages	Cases	Per Cent	Median
11	7	4.63	13 years
12	25	16.55	9 months
13	56	37.08	
14	42	27.81	
15	17	11.25	
16	4	2.64	
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	151	99.96	

3. University of Chicago Elementary and High School Girls

Ages	Cases	Per Cent	Median
11	3	5.35	13 years
12	9	16.06	9 months
13	22	39.28	
14	14	25.00	
15	6	10.71	
16	2	3.57	
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	56	99.97	

4. Baltimore County Girls, Maryland

Ages	Cases	Per Cent	Median
10	3	2.23	13 years
11	10	7.46	8 months
12	27	20.14	
13	40	29.84	
14	36	26.85	
15	13	9.70	
16	5	3.72	
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	134	99.94	

speaking. Children, boys or girls, may be of the same chronological age between $10\frac{1}{2}$ and $16\frac{1}{2}$ and differ in physiological age from one to four or five years and still be normal in physical development. The norm for pubescence is a distribution range, not an average chronological age.

II. At no age do as many as 40 per cent of the groups mature.

III. There is a range in ages from 10 to 17 years for the age of first menstruation for normal girls.

IV. The girls from the country and from the smaller city (11,000 population) mature earlier than those from Chicago and New York, the median ages being respectively 13 years eight months, 13 years seven months, 13 years nine months. This conclusion substantiates the similar condition found for boys (28 p. 15).

2. Relation of Establishment of Maturity to Height of Girls

a. Data. In order to find the correlation from another angle between physical growth and the date of maturity (first menstruation) of girls, 151 Horace Mann girls and 53 University of Chicago high school girls between 11 and 17 years of age were taken, with the heights recorded at the time of the appearance of this physiological function.

It was found for the Horace Mann School, Columbia, that the seven girls who matured at 11 years of age had an average height of 148.2 cm., with the average or norm for the school at 140.39 cm.; the 25 girls who matured at 12 years of age had an average height of 152.1 cm., with the average or norm for the school at 146.22 cm.; the 56 girls maturing at 13 years of age had an average height of 155.3 cm. and the norm was 152.74 cm.; the 42 girls maturing at 14 years of age had an average height of 159.6 cm. and the norm was 156.97 cm.; the 17 girls maturing at 15 years of age were 158.5 cm. in height and the norm was 159.35 cm.; and the four girls maturing at 16 or a comparatively late age were 163.2 cm., while the average for the group was 161.59 cm.

It was found that in working with the data for the 53 girls from the University of Chicago, those who matured at 11 years of age had an average height of 146.9 cm., while the average or norm was 141. The nine who matured at 12 years of age had an average height of 151.4 cm., with the average or norm for the school of 146 cm. The 22 girls who matured at 14 years of age had an average height of 154.7 and the norm was 153 cm. The 14 girls maturing at 14 years of age had an average height of 158.7 cm. and the norm was 157 cm. The six girls who matured at 15 years of age were 159.6 cm. in height and the norm was 159 cm.; and the two girls maturing at 16 or a comparatively late age were 161 cm., with the average for the group 160 cm.

b. Conclusions

I. These results show that girls who mature early are on the average close to the norm or below it. This is contrary to the current belief that early maturation is a sign of poor health.

3. Individual Growth Curves

a. Data. As soon as the wide range of pubescent development in terms of chronological ages is appreciated, the question arises, what underlying principle governs this period of physiological ripening and causes such differences in the phases of physical maturation. This may be made very clear by the following charts taken from a previous investigation (28), where the individual growth curves are given and the establishment of the period of first menstruation is indicated by heavy black dots. It must be recognized that a limited number of type cases are given, but they are all approximately normal. Since these are individual pictures, their validity is established and their worth of permanent value for future analyses. An application of scientific procedure will find several other conditions, such as heredity, social environment, climate, exercise and nationality as important determining factors. The problem here, as in the other sections of this Study, consists in finding the basic facts for further study of the normal child.

In the collected results (Chart LVI) it may be noted that tall girls as a rule mature earlier than short ones. This was shown in the writer's original study (27) by means of individual growth curves.

The individual growth curves in height shown in Chart LVI give some exceptions to this rule, but they demonstrate the law that early maturity means that growth is nearing completion in height as well as sex development. Individuals 4, 5 and 6 should normally mature late, but they matured relatively early and soon after this period there was a diminution in growth. This is very striking in the case of No. 6. Nos. 1, 2, and 3 matured approximately at normal age for their height, since none are tall girls. The tall girls, 1a and 1b, show a striking contrast. The six girls are not only relatively small, but all have had serious illnesses. No. 1 had scarlet fever just before 13 years of age. No. 2 was anaemic throughout her school life, with lumbar curvature, intestinal disturbances and rapid and irregular heart. No. 3, a sister of No. 1, had scarlet fever at the same time, with poor posture during high school period. No. 4, in addition to having had many children's diseases, was very nervous. No. 5 had poor posture, and also had hernia and enlarged tonsils. No. 6 had enlarged glands of the neck and hip disease from a fall. No. 1a and 1b were healthy Chicago girls.

b. Conclusions

I. Tall girls of a fairly homogeneous group, as a general rule mature earlier than short ones.

4. Relation of Maturation to Growth

a. Data. The relation between the cessation of growth and the advent of sex maturity may be shown by a study of the average annual increments of growth between nine and 18 years of age. For the girls who matured at 11 years the increment of growth increased rapidly from nine to 11 and dropped rapidly almost to the one centimeter point at 14. For those girls who matured at 12 years of age, there was an increase in the

average increment until 11, then a slight drop and after 12 a rapid cessation until 15, when it was below the one centimeter increment. For those who matured at 13 there was a slight drop at 10 and an increase until 12, then a drop to less than one centimeter at 16. For those who matured at 14 there was a slight drop until 17, at which age the average is less than one centimeter. For the 15 year old girls there was a relatively high increment until 14 years, when there was a rapid decrease to less than one centimeter at 17. For 16 year old girls the rapid drop also began at 14 years and reached the minimum at 18 years of age. (Data from Horace Mann, University of Chicago and F. W. Parker Schools)

b. Conclusions.

I. Early maturity is followed, as a rule, by a rapid cessation of growth in stature. For girls who mature at 11, a rapid decrease in annual increment follows until 14, where there is less than a centimeter of growth. For those who mature at 12 a rapid decrease in increment follows until 15, when there is less than a centimeter of growth.

II. For girls who mature at 13 or later, the decrease in increment begins in the year previous to maturation, and reaches one centimeter or less three years later.

III. The decrease in yearly increment is more prolonged for girls who mature late.

IV. There is a positive correlation between physiological stages of maturation and anatomical age, as evidenced by height, weight, and the development of the area of the carpal bones.

5. Applications of the Concept of Physiological Age

Six distinct applications of the concept of physiological age in child development may be cited here:

a. To Physical Training. Physiological age has a direct bearing on physical training and directed play. Not only do children naturally play with boys and girls of their same physiological age, but the types of games in which they participate are dependent upon the stage of physiological maturity. It would be justifiable to arrange physical training schedules in schools on the basis of physiological age, giving boys or girls of the same physiological age similar types of exercise. On the average, girls are older physiologically than boys.

b. To Stages of Mental Maturation. Physiological age is, the writer believes, directly correlated with stages of mental maturation. The physiologically more mature child has different attitudes, different types of emotions, different interests, than the child who is physically younger though of the same chronological age. While a child may be precocious intellectually, and have a high intelligence quotient and pass beyond its chronological age in the development of certain mental traits, other types of traits indicative of mental maturity may be undeveloped.

Another experimental study just completed shows that the mental age of the individual bears a direct relationship to the physiological age as indicated by height and weight. The results show that at each chronological age the physiologically accelerated boys and girls have a higher mental age than those of the average or below the average physiological age. The girls, when classified on this basis, show a higher mental age for a given chronological age than do the boys. Girls are on the average mentally older than boys.

c. To School Progress and Promotion. Physiological age has a direct bearing on pedagogical age, as many of our schools are beginning to recognize. The larger and physiologically more mature child may be able to do certain types of school work better, although of inferior ability in specific traits which have been greatly emphasized by school curricula. No child should be promoted or demoted without taking into consideration his or her physiological age. Girls may be expected to progress more rapidly than boys.

d. To Industrial Work. There should be a direct relationship between physiological age and the age at which boys and girls enter industrial work. Child labor legislation should take into consideration the physiological development of the boy or girl as well as his or her chronological age and school standing. Some children are sufficiently mature physically to meet the requirements of an age limit of 14 or 16, while others are immature and in a stage of physiological growth where more school training, more physical training and more opportunity for physical development are essential.

e. To Social Adjustment. That there is a direct relationship between social age and physiological maturity needs only to be mentioned to be evident. Some girls at a given chronological age are sufficiently mature to meet the social conditions which may arise, while others are not. It is apparent that in dealing with children, especially delinquents, between 10 and 18 years of age, there is a tremendous problem involved which rests directly on the physiological age of the individual. Girls face this problem earlier on the average than do boys. In a particular case it may mean a social misfit for life with another child involved, or the individual may be subject to remedial social training and development.

f. To Moral and Religious Awakenings. The commonly observed periods of moral and religious awakening in children, particularly at 12 to 16 years of age, show that there is a close relationship between physiological age and religious development, with girls preceding boys.

PART IV
CHAPTER IX
HISTORICAL ORIENTATION

1. INTRODUCTION

a. General Summaries of Literature on Growth. During the past two centuries there have been many valuable scientific investigations in physical growth, but only a few sustained efforts have been made to make a comprehensive survey of the field, aside from reviews from particular angles. A portion of the literature on growth is summarized in Roberts' (663) Manual of Anthropometry, 1878; Sack's (681) dissertation, 1892; Topinard's (822) Anthropology, 1895; Burk's (136) Growth of Children in Height and Weight, 1898; Macdonald's (490) Experimental Study of Children, 1897; Daffner's (193) Das Wachstum des Menschen, 1902; Ernst and Meumann's (241) Das Schulkind in seiner körperlichen und geistigen Entwicklung, 1906; Vierordt's (846) Anatomische und geistige physikalische Daten und Tabellen, 1906; Weissenberg's (865) Das Wachstum des Menschen, 1911; Baldwin's (27) Physical Growth and School Progress, 1914; Martin's (505) Anthropology, 1914; and Hrdlicka's (405) Physical Anthropology, 1919.

b. International Scope of Contributions. The present status of the scientific literature on physical growth shows many countries contributing, among which are America, England, Scotland, Ireland, Canada, Australia, France, Norway, Denmark, Sweden, Spain, Holland, Belgium, Switzerland, Italy, Germany, Austria, Russia, Poland, Finland, China, Japan, and the Philippine Islands.

The largest amount of scientific material and probably the best, has been gathered or formulated in the United States, England, Germany, France, Russia and the Scandinavian countries, with little from South America and from China directly. Repeated attempts have been made to secure available material through correspondence and conferences. In England the investigations have usually included large numbers of individuals, principally adults, and have been undertaken for practical ethnological, sociological, military and hygienic purposes. In Germany, where more detailed analytical work has been done with children and adults, the point of view is that of the physiological development of the individual. In Russia the physiological and pedagogical points of view have also predominated; in Italy the criminal and pedagogical; in China and Japan the pedagogical; while in Norway, Sweden and the Netherlands the anthropological and pedagogical motivations have been the determining factor. In America, where large numbers of children have been measured and compared in different parts of the country, the work has been done primarily by physicians, anthropologists, anthropometrists, psychologists and educators.

2. EARLY HISTORY OF GROWTH STUDIES

a. General Fields Included. In making an historical survey of the scope, methods and purposes of investigations of physical growth, it may be noted that the scope includes the study of infants, both prenatal and post-natal, children, adults, and occasional comparisons between animals and human beings. The group method has predominated, where different groups of individuals have been measured for different ages and the averages obtained have been supposed to represent consecutive growth periods in the same individual. The literature shows very few studies on a considerable number of cases by the individualizing method. The earliest of these was published by Vahl (832), 1884, followed by that of Landsberger (456), 1888, who measured 37 children for a period of seven years. Then followed Wiener (879), 1890, who measured his four sons consecutively from birth through childhood. In 1910 King (437) presented measurements of his two boys, in one case for six years and in the other for three years. There have been other studies of individual children by Mrs. W. S. Hall, (342), by Major, by Karnitzky (422), Wissler (883), Moon (534 and 535), Boas and Wissler (100), and by Camerer (144-148). Godin (299), 1910, presented the results of four annual measurements on 100 boys. Matthias (507), 1916, investigated the effect of physical exercise on 737 Swiss athletes, each measured three times a year from the age of 16 to 22. Porter (618) in 1920 had obtained weight data on a large number of Boston public school children who had been weighed from 1909 to 1919. The investigations of Baldwin (27 and this Study) follow the individual growth curves for a number of physical traits on several hundred children from various sections of the United States for periods of 10 to 12 years.

b. The Influence of Sculpture and Painting on the Study of Growth. Scientific anthropometry arose mainly from the desire to find the best proportions for the beautiful forms that artists wished to represent. Although no specific references have been found in Greek and Roman literature to actual anthropometric work among these peoples it is evident that the sculptors must have measured the human body in order to make the exact copies of the victors in the athletic games whose statues were customarily placed in temples and public squares and served as examples or norms of perfect physical development. It is known that artists were in the habit of frequenting the gymnasia in order to study the physique of the youths and maidens who were exercising there. Phidias is said to have used twenty models in order that the most beautiful parts of each might be assembled into one figure.

The artistic tradition was carried on by Dürer's (226) folio published in Nuremberg, 1528, which contained much material on human proportions. In 1654 Elsholtz (232) published at Padua his Anthropometria, the first modern work on anthropometry, in which were included pictures of the perfect body and illustrations of anthropometric instruments. Audran (21) published a study at Paris, 1683, which gave the diagrams and measurements of twenty-five famous statues. Bergmüller (55) 1728 wrote one of the early treatises on anthropometry. David (201) 1798, also published material about the famous statues of antiquity.

The historical association of the artistic movement with the interest in anthropometry generally is shown by the fact that in 1770 Sir Joshua Reynolds called attention in an address delivered before the Royal Academy of

Fine Arts to the differences in the measurements of the human form from childhood to adult life. Camper's (157) 1803, works may serve as an example of the earlier modern anatomical treatises. It is to Quetelet, who coined the word anthropometry, that credit should be given for the first scientific study of physical growth. In 1830 were published the results of these first investigations in which the artistic procedure was joined to the new scientific method of empirical measurement and induction. The artistic tradition was continued in such work as that of Fock (256) 1850, who posited Apollo Belvedere as the model for human proportions, and of Story (786) 1866, who gave a detailed study of parts of the body with many allusions to the work of classical scientists, while Schadow's (696) Polyklet, 1834, carried the study of human proportions a step further in that it took account of sex and age and gave actual life sizes.

3. METHODS AND TECHNIQUE

A. LACK OF UNIFORMITY IN METHODS

Since these early studies a vast amount of work has been done in the field of experimental measurements and physical tests. Unfortunately there has been a great lack of uniformity in methods of measuring, standardization of instruments, units of measurement, parts to be measured, topographic points to be accepted, methods of recording data, methods of estimating ages, time of day for measuring, and intervals for repetition of measurement. The English authorities and many Americans have used the inch divided into tenths as a unit measure, although many investigators have used the eighth of an inch. In practically all other countries, the metric, or French system, has been used, with obvious advantages, since the system is the scientific standard used in most countries and in all other departments of science; it is a decimal system and is easily translated into the English system.

There has also been great confusion in the selection of the parts to be measured, since this should be dependent upon the purpose for which the measurements are being taken -- that is, the value to the individual examined, the value to anthropology, the value for the science of physical measurements, the value for an educational program, or the value for correlations with psychological traits. What is needed at present is a standardization of all these factors and a definite statement of the purpose for which each investigation has been made.

B. THEORETICAL DISCUSSIONS AND GENERAL TREATISES ON GROWTH

Many contributions to the theory of anthropometry and numerous considerations of technical questions are to be found in extensive investigations which are listed in later sections of this historical orientation. The summaries of the literature on growth listed in Part VI also contain much material of this kind. The first important special contribution to theory was Galton's (282) short account of an anthropometric laboratory and his (283 and 284) discussion of anthropometric percentiles, 1884 and 1885. Boas (83) in 1894 contributed to the theory of measurements and in 1904 published his discussion of variable quantities (92). In 1894 Pearson (575) wrote on Galton's percentile method. Boas and Wissler (100) 1904, issued their study on statistics of growth which was a continuation of Boas' (91) 1902 statistical study of anthropometry. Weissenberg's (860) anthropometric principles and methods appeared in 1904. As early as 1893 Titchener (821) made a noteworthy distinction between anthropometry and experimental psychology. The latest contribution

to this field in Hrdlicka's (406) articles on the anthropometry of the living in 1919. The recent works of Schütz (707), 1919, in Norway and of Orum (569), 1919, in Denmark, make special contributions to statistical method..

Among the writers of general treatises bearing directly on growth, those that are most significant are Thoma (812 and 813), 1882, Frolick (275), 1896, Ellis (231), 1896, Donaldson (213), 1896, Chamberlain (165) 1900, Thorndike (817) 1901, Buschan (139) 1909, Griffith (321) 1909, Boas (96-98) 1912, Kirkpatrick (440) 1917.

C. MANUALS

A description of the methods of making physical measurement with tables of norms and an account of the general growth process has been published in manual form by Gulick (328), 1892, Megret (516) 1895, Hitchcock, Seeley and Phillips (390) 1900, Hastings (356) 1902, and by Seaver (743) 1909. Books on statistical methods which are applicable to anthropometric work are Davenport's (197) Statistical Methods, 1899, and Thorndike's (818) Mental and Social Measurements.

D. GROWTH FORMULAE

Probably the greatest development in anthropometric methods of recent years has consisted in the extended use of mathematical expressions for various growth phenomena. Beginning with Quetelet in 1836, investigators who have had at their disposal a collection of various measurements of the body on different individuals for an extended series of years, permitting them to calculate the yearly increments, have attempted to express their growth curve by means of a mathematical equation. Since this pioneer work, the derivation of formulae has aided materially in the development of a science of human growth and also in coordinating and correlating the work of the various investigators, especially in reference to total and partial growth of the body. It should be noted that all of the formulae are only approximations, for growth varies in total and partial bodily proportions at different chronological ages, in different sexes, in different races, at different stages of physiological maturation, at different times of the year, and under various environmental and nutritional conditions.

(1) Rate of Growth. One class of these formulae has been designed to express the normal rate of growth throughout life; that is, to give the shape of the curve for relationships of particular measurements such as height or weight. Such formulae rest on the assumption that the normal individual has a certain growth capacity or growth energy at birth. Consequently the value of any measurement at any time of life can be obtained by solving an equation in which certain other values are known. For example, instead of comparing the actual weight of an infant with the norm for its age, the weight it should have at that age may be calculated by filling in the formula. Some writers have constructed tables of norms by making a few determinations and interpolating values that seem to conform to the growth curve as they find it. Accurate formulae, including relationships for more than a few years, have been impossible, particularly previous to this Study, since individual growth curves for childhood have not been available.

Quetelet (626-634) used both classes of formulae, concluding that the weight of the body of the various years of life is proportional to the fifth power of height. The formula is:

$$1. \text{ For Weight. } g = G \sqrt[5]{\frac{5}{L^5}}$$

where

g = weight to be found; G = birth weight; l = height;
 L = birth height.

The increase in weight has also been worked out theoretically by Finkelstein.

2. For height increase Quetelet used the formula:

$$\bar{y} - \frac{y}{1000 (T - y)} - a x - \frac{t + x}{1 + 4/3x} \quad \text{where}$$

x = age in years; y = height corresponding to this;
 t = height of new-born; T = height of adult;
 a = yearly increase between ages 4-16.

An elaborate but somewhat fantastic and inaccurate scheme was devised by Liharzik (474), 1858. The result seemed to indicate that all measurements show that growth takes place in epochs and that in each period of a single epoch the same increase takes place; i.e. if L is the height at birth, this increases in the first month by λ in the second and third months together by λ ; in the fourth, fifth and sixth months by λ . The second epoch begins from the twenty-second to the twenty-eighth month, from the twenty-ninth to the thirty-sixth month, and so on, to 171 months, the increase in each case being still λ . The third epoch has a similar increase. Liharzik's division into epochs and periods with the corresponding months of life was:

I. Epoch 6-5/6 cm. increase

Period	1	2	3	4	5	6
Months	1	3	6	10	15	21

II. Epoch 6 cm. increase

Period	7	8	9	10	11	12	13	14	15	16	17	18
Months	28	36	45	55	66	78	91	105	120	136	153	171

III. Epoch 2 cm. increase.

Period	19	20	21	22	23	24
Months	190	210	231	253	276	300

Liharzik did not work out his formula mathematically but Raudnitz (648), 1892, had Liharzik's measurements worked over by a mathematician who devised formulae.

Zeising (906), 1858, believed that growth in height took place in such a way that the parts of the body were related to each other in the ratio of the golden section. The formula is:

$$x : y :: y : (x + y).$$

Another early mathematical derivation of a growth formula, but without observational material, was made by Kaiser (420), 1875. Attempts have been made to give mathematical expression to the general bio-chemical law of growth. Robertson, (664) 1897, published a growth formula derived from the results

of Quetelet and of the British Anthropometric Committee. It was found that any particular cycle of growth obeys the formula:

$$\log \frac{x}{A - x} = K (t - t_1)$$

where x - amount (in weight or volume) of growth which has been attained during the cycle; K is a constant; and t - time at which the growth due to the cycle is half completed. The author shows that the formula holds true for plants and their elements as well and thinks that growth is an auto-catalyzed process in both inorganic and organic life.

The belief in the parabolic character of the growth curve has led to a considerable amount of discussion. Wiener, 1890, (879) reported continuous measurements on his four sons. Inspection of these measurements led Wiener to the belief that between the ages two and 12 the growth curve is part of a parabola which can be analyzed to give the general formula:

$$y^2 = a (x + b).$$

According to this formula, the axis of the parabola is parallel to the abscissa and its vertex is located to the left of the middle of the system at a distance represented by b , the values of the constants a and b varying somewhat with different individuals. Hall (341), 1895, in a study of the principles of growth by rhythms concludes, "When the vertical dimensions of the human body are undergoing acceleration of their rate of growth, the horizontal dimensions undergo a retardation of their rate of growth, and conversely."

In 1903 von Lange (460) corroborated Wiener's findings in regard to the parabolic characteristics of the curve from two years to the beginning of puberty, but tried to draw an analogy between the laws governing growth and the general laws of motion.

Reinus (651) 1915, in a dissertation under Pfaundler's direction, made an attempt, with different sets of measurements drawn from the literature on growth in height, to find a parabola that would fit the observed facts. Pfaundler (590) 1916-17, working over the data of Friedenthal on the average growth curve of the typical male, found a formula which would express growth in height from birth to the end of puberty. This is:

$$x = n y^3$$

where x = the age in years dating from the time of conception; y = the height in meters; and n = a constant about 4.75 in value. This formula means that age is proportional to the third power of height. By mathematical procedure, Pfaundler also found that when height and density remain constant, weight during the growing period is also proportional to age.

Another type of formula has been developed by workers on the caloric requirements of infants, since the amount of milk to be given at each feeding is to be computed on the basis of the "theoretical weight" for any particular age. Daniels and Byfield (195) 1919, for example, find the

theoretical weight by using the following adaptation of Finkelstein's rule:
 birth weight - (600 X age in months) = 300 - weight for first six months.
 Birth weight - (500 X age in months) = weight for second six months.

(2) Relationships in Growth. A second class of formulae expresses the relationship between two physical traits. The use of these formulae, or better, "indices" is based on the assumption that there is a constant relationship between the growth of the body in the two traits concerned, as for example, in height and in weight. A few investigators have constructed curves showing the value of these indices for each year of life and the curves have been used for diagnostic purposes.

Boulton (108) 1876, though offering no formula, stressed the constant relationship between weight and height and foreshadowed the modern point of view that weight alone is no criterion of normal development. It is the relation of the two expressing robustness that is important. Porter (617) 1896, also emphasized the importance of the height-weight ratio. Ranke (644) 1894-1900, used the following formulae:

$$\text{Weight-height index} = \frac{W}{H}; \quad \text{Vital-height index} = \frac{V}{H}$$

$$\text{Leg-height index} = \frac{L}{H}; \quad \text{Head-height index} = \frac{h}{H}$$

Enebuske (235) 1892-94 assembled or devised formulae for the following relations:

$$\text{Total strength-weight index} = \frac{TS}{W}; \quad \text{Power index} =$$

$$TS \frac{LC}{W}; \quad \text{Vital strength-weight index} = \frac{LC}{W} \times \frac{TS}{W}$$

Oeder (555-557) 1909 and 1910 combined height and weight into an index. Weissenberg (865) 1911, compared thirteen measurements with height and used nine other indices expressing the relations of various parts of the body to each other.

Gaertner (278) 1912, developed a formula to express the relationship of height and weight, computing thereby a table for the normal weight of adult men and women (for each 1 centimeter increase in height).

Tuxford (826) 1917, has used a formula in which the variable factors are:

$$\text{For Boys:} \quad \frac{\text{Weight in grams}}{\text{Height in cms.}} \times \frac{381 - \text{age in months}}{54}$$

$$\text{For Girls:} \quad \frac{\text{Weight in grams}}{\text{Height in cms.}} \times \frac{384 - \text{age in months}}{48}$$

The results are empirical and fall within childhood ages. This writer states that the average for normal children should fall within 990 and 1010.

 

Matusiewicz (508) 1914, also wrote on the height-weight coefficient.

An index relating height and arm span was discussed by Knoop (444) 1918. Feri (252) 1893, developed a relationship between length of trunk and weight.

(3) Total and Partial Growth in Volume. A recent trend has been the development of formulae which should not represent merely linear relationship but should take into account the fact that the body is a three dimensional object. As early as 1879 Meeh (514) began a study of regions or parts of the body to be measured and of the body and total volume, and in 1895 (515) a relationship was shown between the volume of a single part of the body and total volume in infant and adult life.

Among formulae designed to introduce the factor of the third dimension is the "index ponderalis" of Livi (482) 1899. This is:

$$\frac{100}{L} \sqrt[3]{P}$$

where P = weight and L = height.

Another formula takes into consideration chest circumference as well as height and weight. This was introduced by Pignet (598 and 599) in 1900 and 1901 as the "coefficient du robusticité." It has been widely used in the German and French armies. The formula is:

$$N = H - (B \div K)$$

where N = the numerical index; H = height in centimeters; B = chest circumference in centimeters; K = weight in kilograms. When the weight and chest circumference are especially large compared with the height of the individual, the size of the index is small. On the basis of this fact, Pignet divided individuals into seven classes, ranging from the group containing the best developed with a coefficient of 1 to 10, to the group including physical weaklings with a coefficient of above 35. Rarely there occurred cases of over development where the coefficient was zero or negative. Mayet (511 and 512) 1906 and 1912, applied Pignet's formula to children. A report (10) on its use with Chinese and Indian subjects was made in 1916.

Rohrer (671) 1908, emphasized the significance of the quotient obtained by dividing the weight in grams x 100 by the cube of the height in centimeters. This was called the "index der Körperfülle." Bardeen (32) 1918, used a modification of Rohrer's formula, computing an "index of build" by dividing the weight in pounds by the cube of the stature in inches and multiplying the quotient by 1000. This formula was applied to the data of Baldwin (29), using as a general presupposition the assumption that a pound of the body equals a three inch cube. As is well known in physics, the volume of objects of the same shape but of different sizes varies as the cube of their diameters. Bardeen says: "We reach the same result by dividing the weight in pounds by the cube of a tenth of the height or by the thousandth part of the cube of the height in inches. Therefore, as a height-weight index in the study of stature, weight, and body-form, we have adopted the weight of the body in pounds divided by the thousandth part of the cube of the height in inches." Rohrer's formula has also been employed by Berliner (56) 1920. Davenport (199a) recommends

dividing the weight by the square of the height. He unfortunately based his results on Quetelet's inaccurate data of ten cases of each age and the untenable presupposition that short children are on the average stockier. The formula is a very promising one.

In accordance with the same conception of the cubical character of the body, von Pirquet (600) 1913, stressed the height-weight index as a criterion of the individual's nutritional condition. Another formula introduced in 1916 by von Pirquet (601) used the relationship of weight and sitting height thus:

$$\frac{\sqrt[3]{10G}}{S}$$

where G = weight and S = sitting height.

Although a full consideration of formulae for volume, specific gravity, density and cubical content of the body is undesirable in this survey, mention should be made of the work of Braune and Fischer (117) 1889, Mies (525) 1899, Wengler (869) 1906, Kastner (423) 1911-12, Pfaundler (589) 1911-12, (590) 1916-17.

(4) Growth in Surface Area. It is beyond the scope of this investigation to enter into a full account of the subject of the surface area of the body of normal growing children; but reference should be made to a few of the most significant studies, since there is a direct relationship between cutaneous surface and volume and a direct relationship between volume and linear growth and also weight. The surface varies with shape and volume. A student of Vierordt, Meeh (514) 1879, assuming that individuals are similar in shape, and disregarding the differences between infants and adults, proposed the formula:

$$S = K W^{2/3}$$

where S = area; W = weight; and K = a constant based upon the experimenter's data. Seaver (743) 1909, found that a determination of the superficial area of a person which may be of value for special purposes may be found in square centimeters:

$$\text{Sq. cms.} = 11 \times \sqrt[3]{\text{Weight}}^2 \text{ (in grams).}$$

A general survey of work on the determination of body surface was given by Lissauer (480) 1903. Other significant studies are those of von Hösslin (398) 1888, Miwa and Stoeltzner (529) 1898, Sichoff (753) 1902, Maurel (510) 1904, and Lassabliere (465) 1910. Moleschott, Vierordt and Lissauer calculated areas topographically on geometrical principles or used coverings of millimeter paper or tinfoil and measured the amount of covering used, or covered the body with color and transferred the color to absorbant paper and calculated the amount of paper covered. Pfaundler (590) 1916-17, used plaster strips in a similar manner. He (589) also gives a good historical resume. Howland and Dana (400) 1913, have used for infants the formula:

$$Y = 0.483X + 730$$

where Y = body surface in square centimeters; X = weight in grams. Du Bois and Du Bois (220 and 221) 1915 and 1916, and Sawyer, Stone and DuBois (694), disregarding weight and volume, have made the most extensive, empirical studies,

Dividing the total number of days by the number of days in a week gives the number of weeks.

For example, if there are 14 days, then there are 2 weeks.

$$\frac{14}{7} = 2$$

Similarly, if there are 21 days, then there are 3 weeks.

IV. The number of weeks can be found by dividing the total number of days by the number of days in a week.

For example, if there are 28 days, then there are 4 weeks.

Similarly, if there are 35 days, then there are 5 weeks.

Therefore, the number of weeks is equal to the total number of days divided by the number of days in a week.

summarizing the literature of the field. They allowed for the spherical nature of the head, the cylindrical form of the neck, legs and arms, and the cylindrical or spherical tendencies of the trunk at different ages. Benedict (50) 1916, used the silhouette photographs similar to the method worked out by others. Bardeen (32) 1918, using linear measurement, weight and volume, assumed the specific gravity of the body to be 1.000 when dealing with centimeter-gram units and compared the body with a square cross section block. The formula is:

$$S = K \left(2 \frac{W}{H} + 4 \frac{W}{H^2} \right)$$

where S = surface-area, W is weight in grams, H height in centimeters, and K is a constant. In the formula, $\frac{W}{H}$ gives the surface area of each end of the block, $\frac{W}{H^2}$ the surface-area of one side of the block. K has to be determined from the observed surface-area of the individuals, of given height and weight. If inch-pound units are used, one must substitute W x 27.68 for W in the formula given above if the same specific gravity is assumed as in this formula, or W x 27 if one assumes the same specific gravity assumed in dealing with volume. K varies with age, sex and nutritional condition of individuals. For example, for a six months infant, K = 1.53. Bardeen also gives the regional distribution of surface areas.

(5) Graphic Representations of Growth. Closely associated with the introduction of formulae expressive of total or partial growth has been the development of graphic diagrams and charts designed to show on a comparative basis with standards, the physical condition of the person or group of persons. Graphic anthropometry probably originated prior to Quetelet, who showed in graphic form the binomial distribution curve with the mean for specific measurements. Among the investigators who have developed "charting" of physiological traits are: Galton (283 and 284) 1884, 1885, who first showed the significance of percentiles; Stieda (781) 1882-83, whose work was largely theoretical; Sergi (748) 1886, who developed an anthropological cabinet; Bertillon (59 and 60) 1889 and 1896, and Muller (542) 1887, who were particularly interested in the identification of criminals. Jeanneret and Messerli (418) 1917, developed a photo-anthropometric method.

In America the early pioneer work in graphic anthropometry through charts and synoptic tables was developed and fostered by Sargent (680 and 692) 1886 and 1893, and Hitchcock (378-388), whose contributions appeared from 1887 on, Gulick (328-330) 1892 and 1893, Hartwell (350-352) 1893, Jackson (415 and 416) 1892 and 1893, Hastings (354 and 356) 1898 and 1902, and Seaver (743) 1909.

In France, Topinard's (822) L'anthropologie, with its excellent chapters on craniology, appeared in 1895. In Germany there was Friedenthal's (273) Über Wachstum, 1912 and 1913, and two articles by v. Lange (459 and 460) 1896 and 1903.

Among others who have developed graphic charts designed for score cards or norms of physical measurements are Wood (888-893) 1890-1918, Hanna (345) 1893, Kellogg (425) 1893, v. Pirquet (600) 1913, Baldwin (29) 1919, Children's Bureau (168) 1918, and Bardeen (33 and 34) 1920.

Drontschilow (218 and 219) 1914 and 1915, anthropological studies on Bulgarians; Spitzer (770) 1915, Krakau; Bartucz (37) 1916, Magyars.

(3) American. The Americans have recently been less interested in racial differences than in pedagogical anthropometry. The first significant study in America was that of Dickson (207) 1857, continued in 1858 (208), who made detailed statistical observations on the height and weight of the southern men. In 1866 (209) a report showed that the new American race growing out of an almost unlimited mixture of other races compared favorably with all the races of the Old World in every point of physical development, and showed no deterioration. Other studies were made by Bowditch (112) 1890, Massachusetts women; Boas (80, 81 and 85) 1891 and 1895, physical characteristics of the Indians, 1905 (93) anthropometry of central California, 1911 (95) descendants of immigrants, 1920 (102) anthropometry of Porto Rico; Hrdlicka (401 and 403) 1898 and 1899, comparison of white and colored children and 1908 (404) observations on Indians; Bobbitt (103) 1909, Filipinos Bean (42 and 43) 1914-15, American, German-American and Philippine children; Nicholas (550) 1919, a history of physical anthropology in Mexico.

(4) French. In France the interest in racial differences has been a recent development. Convy's (176) 1907, study was followed by Verneau's (843) 1916 work on Africa; Roudenko (678) published in Paris 1914, a study of different portions of Siberia. In 1915 Pittard published three studies (604-606) on the Jews and Turks, on the Jews of Dobrodja and on the races of the Balkan peninsula.

(5) Norwegian. The principal Norwegian investigators of this subject are A. Daae (187) 1906, and H. Daae (187-189) 1909.

(6) Italian. In Italy studies from the anthropological point of view have been made by Bresciani-Turroni (120) 1913, on different regions in Italy; Guiffrida-Ruggeri (296) 1915, Oriental Africa.

(7) Russian. Among the important Russian studies are those of Blagoviddoff (76) 1886, on the Mongolian Asiatic races; and Szepepsi (798) 1897, on the Magyars. So many Russian dissertations within this field are inaccessible that no direct comparison can be made here.

(8) Japanese. Almost the only Japanese investigations undertaken primarily from the anthropological point of view are those by Kubo (452-454) 1912-1918, on the Chinese and on the Koreans.

(9) Dutch. In the Netherlands contributions have been made by Nieuwenhuijs (551) 1903 and Witt (884) Netherlands.

(10) South American. The beginning of anthropometric work in South America is represented by a study of Cassenilli (162) 1917-18, on Argentina.

B. GROWTH OF ANIMALS AND MAN

Few studies have been made on the relationship between the growth of animals and human beings, but those that have been made are significant and full of scientific data. An early contribution was published by Menard (517) 1885, Donaldson (214) 1906, made a comparison between the white rat and man with respect to the growth of the entire body, and further studies are in progress;

4. ANTHROPOLOGICAL INVESTIGATIONS

A. NATIONAL CONTRIBUTIONS ON RACIAL DIFFERENCES

No attempt will be made in this section of the historical summary to give an exhaustive account of the anthropological studies on the physique of different races, but note will be made of the most significant investigations classified according to their place of publication, and the tables in Part V will give the data for comparative studies in racial development for the reader who is concerned with this phase of human development.

(1) English. Numerous important contributions have been published in England. Brent (118) 1844, made before the British Association for the Advancement of Science a comparison of men at different epochs in different countries. In the following year tables were presented (119) showing the height, weight and strength of man. Quetelet (629 and 630) 1846 and 1847, presented a study of some Ojib-be-was Indians, in 1848 (631) a discussion on the Egyptians, Romans and Indians and in 1854 (632) a study of the proportions of the black race.

Thomson (816) in 1853 published some observations on New Zealanders. In 1861 Beddoe (44) discussed the physical characteristics of Jews before the Ethnological Society of London, in 1870 (45) reported on the stature and bulk of men in the British Isles, and 1897-98 made a study with Moore (537).

Other important articles are by: Shortt (751) 1863, a comparative study of Europeans and some natives of India; Brigham (124) 1866, a study of Chinese. Farr (245) 1880, and Galton (284) 1884-85, data on the English race; Forbes (257) 1884-85, on the Kubers of Sumatra, Garson (290) 1890, further data of the anthropometric committee on which Farr and Galton worked; Haddon (337) 1897, comparative study on the inhabitants of Barley, Hertz; Gregor (318) 1897, comparative study of Galloway folk in Wightshire and Kirkenbrightshire; Grünbaum (326) 1897, on the physical characteristics of the inhabitants of Barington and Foxton in Cambridgeshire; Taylor (803) 1897, on the inhabitants of Check-heaton, Yorkshire; Brown (127) 1897, inhabitants of Clara Island, Ireland; Meyers (545-547) 1905-08, on Egyptians; Rasmussen (647) 1908-09, Eskimos; Orensteen (566) 1915-17, detailed individual studies of Egyptian prisoners from Cairo; Craig's (180) earlier use of this same Egyptian material in 1911; Talbot (799) 1916, some central Sudan tribes; Seligman (747) 1917, physical characters of the Arabs.

(2) German. In Germany there have been fewer anthropological studies made primarily for the purpose of finding racial differences. Many anthropometrical observations have been made by members of expeditions for other scientific purposes. As examples, may be mentioned the work of Schwarz (735) 1862, And Wullerstorff-Urbair (896) 1857-59. Other studies have been made by Schultz (728) 1845, on Russian Jews and Negroes; Scherzer and Schwarz (699) 1859, Vienna; Ecker (227) 1876, Baden; Kirchhoff (438) 1892-93, comparative studies of the Germans; Stratz (787) 1898, Java; Hagen (338) 1901, Chinese; Ranke (642) 1906, Brazil; Lipiec (478 and 479) 1912, Jews; Schiff (701) 1914, Jews from Jerusalem; Weissenberg (859, 863, 866) 1895, 1909, and 1914, Armenians and Jews; Radlauer (638) 1914-15, the Somali; Schlaginhaufen (711) 1914, New Guinea;

Friedenthal (267-272) 1909 and 1911, published curves on the growth of man and other animals, indicating great similarity between man and the anthropoid ape, and in 1914 summarized much work in his large volume (274). Haustein, 1916, (359) discussed devices for representing the growth of man and animals by measurements and drawings.

C. MILITARY STUDIES

The measurement of recruits of the army and navy has always held a prominent place in the development of physical anthropometry, and several million individuals have been measured in various countries.

France. Considering first the army, it is found that the first modern study was that of Villerme (847) in 1829, who made a careful study of the height of conscripts in the French service. In 1863 Boudin (107) published a comparative ethnological study, later followed by Chervin (167) 1896, Merz (520) 1901, and Kirkoff (439) 1906.

England. Aitken (2) 1862, published studies on the growth of the young British soldier; the British Army Medical Department (125) reports for 1894, 1895, and 1901, contain important material. Myers' (546) measurements of Egyptian recruits appeared in 1906. A Physical Census in England its Lesson (11) which appeared anonymously in 1918, analysed the data on drafted men in the recent war.

America. One of the earliest military studies in America was Elliott's (230) analysis in 1863, of the physical measurements of soldiers in the American army of the Potomac. The most exhaustive studies in America were those of Gould (311) 1869, Baxter (39) 1875, Sternberg (779) 1893, and Beyer (64) 1896. French (265) 1885, and Dun (225) 1887, made a special study of the police standard. In 1918 Hoffman (391) presented a study on men rejected for military service. In 1919 Ireland, Love and Davenport (412) showed the results of the physical examination of men sent to mobilization camps, and in 1920 Davenport and Love (200) discussed defects found in drafted men in the recent world war.

Germany. German military anthropometry is represented by a number of investigations from the time of Ranke (643) in 1881. He was followed by Ammon (7 and 8) 1890 and 1894, Hultkrantz (407) 1896, Brandt (116) 1898, von Schjerning (710) 1910, Kulka (455) 1912, and Drontschilow (218) 1914. Special interest has been shown in the possibility of using indices as means for the physical examination of recruits. Schwiening (738-740) 1908, 1909, and 1914, advocated the use of Pignet's formula, and Oeder (558) 1914, discussed his work. Eulenberg (242) 1910, found Pignet's formula unsuitable for individual cases. Ott (571) 1911, and Simon (760) 1912, used the formula, while Seyffarth (749) 1911, considered it useful for rapid surveys.

Russia, Italy, Norway, Denmark. Forssberg (259) 1897, Starkow (774) 1897, Yatsuta (899) 1914, made important Russian investigations. Livi's (481) Italian article appeared in 1894. In Norway there is Koren's study (447) 1901; and in Denmark Mackeprang's (494) investigation, 1907-11.

Naval cadets. Among the important studies of naval cadets are those of Morskoi (540) 1871. Gihon (293) 1880, Cordeiro (177) 1887, Beyer (61-64) 1893-1896, Williams (881) 1902, and Solhaug (766) 1920.

5. GROWTH OF INFANTS

The first studies in anthropometric measurements of infants were those of Roederer (670) in 1753, Clarke (172) 1786, and Pfannkueh (588a) 1874.

A. TREND OF GROWTH CURVES

Quetelet's (628) comprehensive survey of human development in 1836 included the growth of babies. Just as this investigator failed to discover the sex differences in the growth of older children, owing perhaps to having determined too few points on the growth curve, so also there was no recognition of the exceedingly steep rise in the early part of the curve during infancy. Quetelet seems to have been under the impression that this curve was a straight line connecting three points for which measurements had been taken: birth, twelve months and twenty-four months. This belief in regard to the first year, at least, is expressed as follows in Recherches sur le poids de l'homme aux differents ages, 1833, where it states "Pendant la premiere annee son poids s'accroit regulierement, de telle sorte, qu'en un son poids a triple."

B. POSTNATAL LOSS IN WEIGHT

After Quetelet's reports, the problem of determining the general trend of the growth curves was neglected for a number of years while investigators occupied themselves with the explanation of the so-called "physiological loss of weight" in the first few days of life. Chaussier is credited by many authors with having been the first to discover that infants lose weight for a few days after birth. These observations must have been made between 1815 and 1830, but nowhere in the literature is an exact reference given. One of the earliest accessible studies is by Hofmann (393) in 1849. In 1860 both Breslau (121) and v. Siebold (754) wrote on the subject. Important investigators who followed, giving particular attention to this problem, generally from a medical point of view, are: Haake (335) 1862; Winckel (882) 1862; Gregory (319) 1871; Kezmarsky (434) 1873; Altherr (6) 1874, Kruger (451) Ingersley (411) and also Cnopf (173) 1875, gave an historical resume; Stoll (784) 1876; Wolff (886) 1883, and also Biedert (67) 1883, added to a mere record of the phenomenon some consideration of the factors that influence the change in weight. Wagner (852) 1884, and Townsend (9824) 1887, continued the discussion of the cause of the loss. Schaeffer (697) 1896, presented a statistical analysis of causes, and Fourmann (262) 1901, a discussion of causation. They were followed in 1903 by Schulz (729); Fuhrmann (277) 1907; Heidemann (363), Hirsch (377) Rott (677), Pies (597) 1910; and Orum (568) 1914. Benestad (51 and 52 1913 and 1914, published an excellent review of the literature and a classification of factors of causation under the head of insufficiency of metabolism. Robertson (665 and 666) 1914 and 1915, attributed the loss to mechanical shock. His work was followed by that of Bergmann (54) 1916, Schick (700) 1917 and Hammett (344) 1918, the last of whom found the loss to be a function of birth weight. Other recent writers are Kirstein (441 and 442) 1917 and 1918, Haverschmidt (360) 1917, and Ramsey and Alley (641) 1918.

Many of these writers noted simply the phenomenon of loss by daily weighing of infants. Others attempted to account for the loss by an analysis of the physical and mechanical factors influencing weight, and the development of a better technique of weighing with reference to time of day, consumption of food, loss of organic products, etc. As a lengthy discussion of these factors is beyond the province of this work, reference should be made to the thorough treatment of Benestad (52)

C. GENERAL VS. INDIVIDUAL METHODS FOR STUDYING WEIGHT AND HEIGHT

After the early interest in the problems of fluctuations in weight, the attention of scientific writers was turned to the determination of the general curve of growth for infants. Probably the first systematic attempt to find average weights for every month in the first year of life was made by Bouchaud (106) in 1864. This line of work was continued by Fleischmann (254) 1877, whose article is of interest historically as an early example of the "individualizing method" with its insistence upon following the same individuals throughout the period observed, instead of making a few determinations and interpolating values according to some formula in the manner that diverted Quetelet from the main problem. The individualizing method occurs only very rarely in the literature. Most of the workers on this problem of the total growth curve have used the method of averages; many have combined males and females, and practically none give average deviations.

Early writers had noted as a characteristic change in the rate of growth a general slowing down, shown by a rapid fall in the curve of increments after the first year, and had emphasized the importance of sex differences. An early study by the individualizing method was made by Woronichin (894) 1880-81. In the study of the general growth curve, the technique of the individualizing method was developed to a relatively high degree by Camerer, senior. In 1880 Camerer (144) published a short study of infant weight; in 1882 he (145) extended Vierordt's collection of cases from the literature and added data from his own practice; in 1893 he (146) reviewed the results and in 1899 his son (150) presented a summary of 283 cases. In 1901 Camerer senior (148) published the original tables for 119 of these cases. Karnitzky (422) 1908 and King (437) 1910, also reported measurements by the individualizing method on particular children.

Other much less extensive studies by the generalizing method were published as follows: Odier (554) 1863; Uffelman (830) 1881; Pfeiffer (591) 1884; Morse (539) 1886-87; Chaille (164) 1886-87; Peterson (598) 1887; Lorey (486) 1888; Voute (851) 1895-96; ten Siethoff (757) and Graanboom (312) 1899; Perret and Planchon (587) 1904; Ausset (22) 1904; Fleischner (255) 1906; Lascoux (464) 1908; Heubner (375) 1911 (general summary); Friedenthal (270) 1911; Mayet (512) 1912; Pooler (609) 1913; Robertson (669) 1916; Broudic (126) 1919; and Faber (244) 1920. A recent undated collection of measurements by Crum (185) contains fairly reliable assembled average standards beginning at six months.

The early literature contained very few studies on the height of infants. In 1860 von Siebold (754) gave the birth length, together with the weight, but it was not until 1881 that a table by Hess (374) included a few determinations of height in the continuous series of measurements

of a child from birth to two years. Schenk (726) 1880 gave the birth length of 300 cases, and Mrs. Hall (342) 1896-97, gave height measurements for one case throughout one year. Camerer almost always reported height as well as weight in his studies. Fleischner (255) 1906, related weight to height and other measurements. Lascoux (464) 1908, Mayet (512) and Crum (185) gave height measurements. Breslau (122) 1862, was interested in sex differences in head circumference. Of special studies concerning the interrelationship of various measurements during growth, that of Zeltner (909) 1911, is an example. In 1914 Montague and Hollingworth (530) made a comparative study of the variability of the sexes at birth and found no inherent sex differences.

D. INFLUENCE OF NUTRITION ON GROWTH

In addition to these general investigations of growth in weight and height, a number of significant studies were made on the effect of special conditions, among which diet early received scientific consideration. The first work upon this phase of the subject seems to have been done by Coudreau (178) 1869. He was followed by Faye (247) 1874, and by Ahlfeldt (1) 1878. The individualizing method was used in this field by Camerer and Hartmann (153) 1878. Their work furnished determinations actually made (and in a few cases calculated) for every day of the first year of an individual infant's life. This new point of view is exemplified also in the study of Hahner, (339) 1880, who weighed an infant before and after each feeding to determine the exact amount of food taken, with the resulting effect on growth during the first year.

The problem of the relative advantages of breast and artificial feeding come to the foreground in such work as that of Russow (680) 1881 and Sakuragi (685) 1908. Philippson (596) 1913, gave weight curves for artificially fed infants, and Sieveking (758) 1914-15, published tables for both the breast and artificially fed. Contrary to Russow's findings in regard to the superior development of breast fed infants, Hillenberg (376) 1912-13, and Variot and Fliniaux (840) 1914, reported only a small difference between the breast fed and the artificially fed.

For the numerous articles on the caloric requirements of infants, Oppenheimer's (565) 1901, may serve as an example. Other works on the relation between nutrition and growth have been published by Rubner (679), Muhlmann (541) 1910, Langstein (462), Meyer (522) and Schloss (717) -- all 1912; Bamberg (31), Brady (115), Herman (367), Jaschke (417) 1913; Opitz (562) 1914, Schute (731) 1915. Within the last few years a fertile field of investigation has been opened by the discovery of the special growth-stimulating properties of certain diets. Hammett and McNeile (343) 1917, observed the effect of the mother's ingestion of dessicated placenta in hastening the infant's recovery from the postnatal decline in weight.

The work of Daniels and Byfield (195 and 141) 1919-20, showed the effect of the anti-neuritic vitamin in stimulating growth. Among general treatises on the relation between nutrition and growth processes, both normal and pathological, might be mentioned those of v.d. Bergh (53) 1893, Marfan (501) 1899, Judson and Gittings (419) 1902, Schloss (715-717) 1910, 1911, and 1912, and Langstein and Meyer (463) 1914. The handbooks of Holt (396) and of Griffith (321 and 323) have gone through numerous editions within the last decade.

E. PATHOLOGICAL CONDITIONS AFFECTING GROWTH

Studies of the effect of pathological conditions on height made by Variot (835-837) 1907 and 1908, showed that a "dissociation of growth" might take place with a continuous increase in height, although weight was seriously affected; Freund (266) 1909, corroborated this; Birk (75) 1911, found, however, that with very young children height was unfavorably affected. Stolte (785) 1913, and Aron (16) 1914, also found height to be somewhat affected, though less so than weight.

Hess (373) 1915-17 showed the effect of antiscorbutic diets on weight in infantile scurvy. Eddy and Roper (228) 1917, stimulated growth in cases of marasmus by the use of pancreatic vitamin. The work of Daniels and Byfield (195 and 141) 1919-20, has already been mentioned. At the present time it seems probably that a significant advance in knowledge concerning growth is hortly to be made in this field.

F. INFLUENCE OF SPECIAL CONDITIONS ON GROWTH

Among other special conditions whose relation to growth has been studied, are dentition-- Woronichin (894) 1880-81; military fitness of father-- Schmid-Monnard (718) 1892; institution vs. family life-- Freeman (264) 1914; season-- Bleyer (77) 1917; war conditions-- Brüning (129) 1918, Pollak (608) 1918, and Hoffman (392) 1918.

A number of writers have reported birth measurements in relation to special problems: Among these are: the age of the mother -- Hecker (361) 1865; Faye and Vogt (249) 1866; Stockton-Hough (783) 1885-86; Lange-Nielsen (461) 1918; nationality -- Okamoto (560) 1894; Robertson (667) 1915; order of birth -- Siesel (756) 1905; occupation and social class of parents -- Letourneur (472) 1897; Issmer (413) 1899; Fuchs (276) 1899; Weissenberg (861) 1908; Goldfeld (307) 1912; Peller (584) 1913; length of pregnancy -- Astengo (19) 1905; Christofferson (170) 1905; Lutz (489) 1912; Kjolseth (443) 1913; correlations of measurements -- Pearson (576) 1900; Peller (585) 1917; and Taylor (805) 1918.

Birth measurements have also been reported by Scanzoni (695) 1849, Veit (842) 1855, Hecker (362) 1866, Martin (503) 1867, Cnopf (173) 1871, Witzinger (885) 1876, Schütz (732) 1881, Spiegelberg (767) 1882, Kåzmarsky (434) and 435) 1873-1884, Körber (446) 1884, Schroder (727) 1886, Mies (524) 1891, Miller (527) 1893, Sfameni (750) 1901, Warren (857) 1917.

G. FOETAL GROWTH

Considerable work has been done on foetal growth, but this problem is beyond the province of our present discussion and the reader is referred to Jackson (414) 1909, and Scammon's unpublished work.

6. NATIONAL CONTRIBUTIONS ON PHENOMENA OF TOTAL GROWTH OR PARTIAL GROWTH

Studies on the general phenomena of physical growth as surveyed from the early work of Bird (74) 1823, may be differentiated into innumerable problems and sub-problems. In the main the object has been to determine how

on the growth of the body and its parts, a point of view which has been consistently emphasized and which characterizes the most modern books of Daffner (193) 1902, Ranke (644) 1894-1900, Weissenberg (865) 1911, and of Hoesch-Ernst and Meumann (241) 1906. Kotelmann's (449) first investigations bearing on hygiene were published in 1879; Hensen (365) 1881, discussed the subject from a physiological point of view; Daffner's work began to appear in 1884 (190 and 191) and was continued by a publication of 1892-93 (192). Two studies on the growth of boys by Landsberger (456 and 457) appeared in 1888. Weitzel's (867) measurements of girls were published 1890-91 at the same time as Wiener's (879) individual study.

Other important studies have been made by Carstadt (160) 1888; Hasse (353) 1891; Schmidt (724) 1892; Camerer (146) 1893; Weissenberg (859) 1895; Hergel (366) 1897; Monti (532) 1898; Salomon (686) 1898; Schmid-Monnard (722 and 723) 1900 and 1901; Rietz (657) 1903; Reuter (653) 1903; Ranke (645 and 646) 1905; Stratz (788-794) 1908, 1911, 1912, 1914 and 1915; Schwerz (736 and 737) 1911 and 1912; Wagner (853) 1911; Ascher (18) 1912; Peiper (582 and 583) 1911 and 1912; Cohn (174) 1912; Riedel (656) 1913; Munch (544) 1914; Skibinski (763) 1914; Matusiewicz (508) 1914; Guttmann (334) 1915; and Schlesinger (713 and 714) 1917.

An important collection of tables from various sources was published by Vierordt (846) in 1906. Bachauer and Lampert (23) 1919, proposed a comprehensive program for a system of measurements on children.

(5) Russia. In Russia much valuable anthropometric work has been done, but as previously stated, only a limited number of investigations have been accessible, and no doubt during the last few years a large number of these may have been destroyed. Many valuable studies are in the form of Doctor's dissertations which are filed in the archives of various libraries and have been referred to principally through the work of Sack and Wiazemsky, who seldom give the exact title, number of pages, date or place of publication.

Vassiliev (841) published an early study on girls, 1881. In 1882 Dudrewiez (223) made anthropometrical measurements of children in Warsaw; Diek (210) 1883, made a more comprehensive study and in 1886 Belaiew (47) studied the children of Simbirsk. Other studies are as follows: in 1887 Suligowski (796) pupils in Radom; in 1890 Sograf (765) in Jaroslav, Kostroma and Vladimir provinces; in 1890 Milailow (526) Moscow; in 1892 Grinevski (324) Odessa; in 1892 and 1893 Sack (681-684) Moscow; in 1894 Vinogradorsk-Lukersk (849) general study of high school pupils; in 1895 Matveyeva (509) St. Petersburg; in 1896 Tezyakoff (809) in Yelisavetgrad County; in 1900 Rostovtsev (674) in Dmitrovsk; in 1902 Bondyrew (105); in 1903 Karnikki (421); in 1905 Pismennry (602) Serpukhor County. Gundobin's (331) book on the characteristics of childhood, was published in 1905, Wiazemsky's (878) Paris dissertation on physical growth of Russian children appeared in 1907, Berlinerblau's (57) study of an orphanage, Moscow, 1908, Gruzdeff's (327) 1912, and Gorokhoff's (310), 1916. Anutschin's (14) general study of the male population of Russia and Mereshoffsky's (518) on the development of children, appeared prior to Sack's dissertation, 1892, where they are cited without dates.

(6) Italy. In Italy an early investigation from the sociological point of view was made by Pagliani (573 and 574) 1875-76 and 1879. The Bertillon (59 and 60) system of criminal measurement was described in French in 1889 and in English in 1896. The chief pedagogical studies have been made by Santori

(688) 1907, and Montessori (531) 1913.

(7) China and Japan. An anthropometric study of Chinese students was made by Merrins (519) 1910. With a view to developing norms for the Chinese race, the Medical Missionary Association has initiated anthropometric investigations, the first results of which were reported by Whyte (875-876) 1917 and 1918. Pyle (625) published in America, 1918, a comparison between American and Chinese children. In Japan three very important studies have been made by Miwa (529) 1893, of individuals from three to 80 years; Misawa (528) 1909, made a study of 869,014 children; and Hatta (358) recently made a report on 786 Japanese boys. A comparative study of Japanese and Chinese children appeared in 1903, by Wood (887). At the American University at Peking, Cowdry is beginning work under the direction of the Smithsonian Institution at Washington.

(8) Spain. Little work has been done in Spain, but reference should be made to the work of Arthaud (17) in 1895.

(9) Norway, Sweden and Denmark. Studies of the growth of the Scandinavian people have been made in Norway by Faye (248) 1914 Schiotz (704-709) 1917, and Zeiner-Hendriksen (903 and 904) 1918 and 1920; in Sweden by Wietlind (880) 1878; Tornell (823) 1909, and by Sundell (797) 1917. In Denmark the years 1907-11 saw a number of investigations by Hansen (347), Rambusch (640) and Hertz (371).

(10) Netherlands. In the Netherlands a study of the height of males was made in 1910 by Bolk (104); a more general study of the male population in 1916 by Benders (49); and an investigation of the weight of children by Van der Loo (485), 1919.

(11) Finland. In Finland an important study by Oker-Blom (561) appeared in 1912.

(12) America. (a) School Children. The interest in pedagogical anthropometry which has had such an influence on school administration probably began in America with Bowditch's (109 and 110) reports to the Massachusetts Board of Health, 1875 and 1879, in which were analysed the statistics on thousands of school children to show the influence of nationality and social class. Equally fundamental for the establishment of the new concept of the growth process were reports on the physique of women (112) 1890, and on the growth of children studied by Galton's percentile grades (113) 1891. Later work was that of Peckham (580 and 581) 1881 and 1882, whose reports to the Wisconsin Board of Health included many valuable statistics on growth. In 1887 Stephenson (777) published a brief account of the rate of growth in children. Greenwood's Kansas City studies (317) 1890 to 1892, gave the height and weight of a large number of children. Boas' (82) Worcester study, 1892, discovered some important differences in the growth of young and older, and of tall and short children. Jackson (415) in 1892 published tables of the measurements of Easthampton students. Barnes's (35) California study, 1892-93 showed that Oakland children surpassed in physical development children from other localities studied up to this time. Moon (533-535) presented brief studies of Maryland boys, 1892 and 1896. Porter's (611-615) St. Louis studies appeared 1892 to 1894.

In 1893 and 1894 West (870-872) made some important observations of the growth of the head, body and face of Worcester, Mass., school children. Seaver (742) 1895-96, presented some new anthropometrical data. Boas' (84) conclusions about the advantage in growth held by first-born children resulting from an analysis of the Oakland and Toronto data were published in 1895 and subsequent findings (88) in 1897. Burk (136) published in 1898 a good summary and comparison of previous work on growth. Boas and Wissler's (100) elaborate collection and analysis of statistics on growth appeared in 1904. Gardiner and Hoagland (289) 1903, discussed the growth of California children. Robertson (669) further analysed the Oakland statistics in 1916. Holt's (397) comparative study appeared in 1918.

(b) College Students. In the standardization of anthropometric methods and instruments and in the securing of reliable data for the establishment of standards and norms, the physical training departments of colleges and universities have contributed substantial scientific data. The study of college students was begun at Marlborough College in 1874, by Fergus and Rodwell (251). In 1888 Hitchcock (380-389) started important studies at Amherst College, which were continued through 1893. Tuckermann (825) published some of the Amherst data in 1888. Seaver (741) 1889, issued a table of percentile values for fifty different measurements on Yale students ranging between 16 and 21 years of age. Sargent at Harvard has been working for years in an effort to determine the proportions of the typical man (690) 1887, scholar and athletes (693) 1908, and the typical woman (691) 1889. A series of charts (692) summing up these measurements appeared in 1893. At Wellesley College, Wood (888-892) 1890 to 1903, published tabulated data on the physical development of college women and Enebuske (235) 1894, gave measurements of normal school students of physical training. There followed investigations at Bryn Mawr by Hurd (408) 1891, and by Foster (260) 1898; at Oberlin by Hanna (345) 1893; at Haverford by Hall (341) 1898; at the University of Nebraska by Barr (36) 1903; at Ann Arbor by Bean (41) 1907-08; at Oxford by Schuster (730) 1911. Elson (235) 1910, presented some statistics on special students in an agricultural college.

B. PARTIAL AND TOTAL GROWTH

A number of special studies have been made on the growth of particular parts of the body, on the proportions of the body during growth and on the correlations of different physical measurements during the years of growth. In the year 1854 this problem of proportions was discussed both by Carnus (161) and by Zeising (905-908) whose work continued into 1859. In 1862 Melkner (868) investigated the growth of the head and Angerstein (9) 1865, made a general contribution to the theory of proportions.

Quetelet's (629-632) studies, 1846-1854, which have previously been classed under the head of racial differences, were continued by some general discussions (633 and 634) in 1870. There followed studies by Dally (194) 1872, Kotelmann (449) 1879, Lucas (488) 1882, Thomas (812) 1882, Oppenheimer (564) 1888, Hansen, (346) 1891-92, Anthony (13) 1894, Tichanoff (820) 1894, Richards and Little (654) 1896, Ripley (659) 1896,

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111

on the forms of the head and Boas (87) 1897, with a discussion of Ripley's article, Roshdestwensky (673) 1897, Binet (69) 1901, on the growth of head and face, Teumin (808) 1902, Manouvrier (500) 1902, Pfitzner (595) 1903, Seggel (744 and 745) 1903, Wissler (883) 1903, Rose (672) 1905, Laumonier (466) 1909, Weissenberg (862 and 864) 1909 and 1910.

Among recent correlation studies are those by Alfeyeff (4) 1912, weight, height and chest measurements; Weisse (858) 1912, chest and abdominal measurements in relation to build; Downes (217) 1913-14, trunk measurements and stature; Levy, Magnan and Sellet (473) 1914, height and chest circumference; Walker (854) 1915, relation of weight to body length. Baldwin has presented in this Study, pages 117 to 148 numerous coefficients of correlation for physical measurements.

C. PERIODS OF GROWTH.

Attempts have been made from time to time by various investigators to divide the growth process into periods or stages of development. Bryan (132) 1900, has given a review of such attempts and discussed the significance of such stages in growth. It is, however, very undesirable to try to divide the years of average growth in any such manner as was attempted by Vierordt, Liharzik, Zeising or Key, since growth is a continuous process with no abrupt step from stage to stage. Individual and sex differences and variations in growth due to physiological maturity, heredity and racial, social and individual type still further complicate the problem. It is still an open question whether it will be possible with adequate data consisting of repeated measurements on a sufficient number of children for a considerable period of time to outline such periods in the growth of normal children.

7. CONDITIONS AFFECTING GROWTH

A. CLIMATE AND SEASON.

Few definite scientific data are available concerning the influence of season and climate on physical growth, since the problem is a difficult one to solve without consecutive measurements on the same group of individuals. In 1875 Baxter (39) made an important study for the Provost General's Bureau, which showed that the size of adult Americans is different in different parts of the United States, this being attributed to the influence of climate on growth. The best work was started by Malling-Hansen (497) 1883, in which an exhaustive and careful treatment was made of periodicity in the weight of children who were measured daily. This article was followed by an address before an international medical congress at Copenhagen on the effects of change of diet on growth at different times of the year (498). In 1886 Malling-Hansen (499) published a somewhat fantastic treatise on variations in weight coincident with variations in the heat of the sun's rays, in which it was found that for weight the greatest growth was from August to the middle of September and the least during May, June and July, while for height the reverse was true. Voit (850) 1886 and Zacharias (901) 1889, discussed these results. Vahl (832) 1884, discovered, for children in a girls' school weighed semi-annually from 1874 to 1883, that

there was a greater increase in weight in summer than in winter. Schmid-Monnard (719 and 720) 1895 and 1896, found Malling-Hansen's "periods" characteristic of German children. Gray (315) 1910, published his Diurnal Variations in Weight as a Bachelor's thesis; Makower (496) 1914, substantiated the Schmid-Monnard thesis by a study of 400 Jewish children; Orum (568) found seasonal variations in weight, 1914; Lentz (470) 1917, showed that for German children April, May and September were best for general health, while November and December were worst.

Hall (340) quotes Zak (Sack?) as finding height decreasing during the day and weight increasing, and Vierordt (845) found weekly or half weekly periods repeating themselves. Pittard (603) 1906, also discussed the influence of geographical milieu upon height. Porter's (618) investigation in 1920 shows that for American children the increase in weight is greater from June to December than from December to June.

B. EFFECTS OF WAR

In Germany, where the food shortage was especially acute, school physicians and health authorities have undertaken numerous investigations to discover whether the growth and nutrition of children were suffering. Some of these reports are documents of a political and controversial nature, but a certain number are deserving of scientific attention. The studies made in 1916 by Haberlin (336), Schlesinger (712), Lommel (483 and 484), Gohde (306) and Thiele (811) showed that no harmful effects of the food shortage had yet become apparent. Herzog (372) 1916, and Engelhorn (236) in the same year, even claimed was children to be in somewhat better condition, probably because of the war time emphasis on hygiene and the more sensible diet. These results were confirmed for 1917 by Oschmann (570) and Lubsen (487) and for 1919 by SiegmundSchultze (755) and Poetter (607). Other investigators showed, however, that especially during the later years of the war, bad conditions were beginning to have their effect. Kettner (429) found that as early as 1915 a decrease in the growth of children was apparent and Engelhorn (237) 1916-17, discovered that city children were in somewhat poorer condition than during the second year of the war. Davidsohn (202) 1920, found a decrease in growth and Pfaundler as reported in an anonymous editorial (12) in 1919 showed that boys and girls grew less during the war and that the average decrease in gain was more conspicuous in children of professional classes.

Among French investigations a research made by Bleyer (78) for the American Red Cross Children's Bureau showed that the children of Vienne, a manufacturing town of France, were in good condition in 1919. DuBois (222) 1919, published some data on the children of Liège. In England Howard (399) 1919, discussed war bread and the growth of children.

C. SOCIAL STATUS

Whether the good development of children from the favored classes is due to environmental influences including diet and medical

1. The first part of the report
describes the general situation
of the country and the
main problems which
are facing it.

2. The second part
deals with the
economic situation
and the
financial resources.

3. The third part
describes the
social situation
and the
cultural life.
It also
mentions the
health and
education
services.
The fourth part
deals with the
environmental
situation and
the natural
resources.
The fifth part
describes the
political situation
and the
government.
The sixth part
deals with the
international
relations.
The seventh part
describes the
future prospects
and the
conclusions.

4. The eighth part
deals with the
conclusions and
recommendations.

5. The ninth part
describes the
appendices.

inspection or to superior heredity is a question that cannot be settled with the data at hand. The superiority in development is the common report of investigators. As early as 1829 Villerme (847 & 848) showed that good homes and good nutrition contribute materially to physical growth. Bowditch (110) 1879, showed that the "favored classes" with good nutrition are superior to general classes, especially in height. This view was also held by Roberts (663) 1878, by the Anthropometric Committee of England under the chairmanship of Galton (281) 1883, by the Danish Commission under Hertel (368 and 370) 1882, by Geissler and Uhlitzsch (291) 1888, and by Geissler (292) 1892, by Eismann (239 and 240) in Russia 1888, and by Key (430) in Sweden, 1885. Stanway (773) 1833, published the results of investigations into the comparative health and condition of factory and non-factory children of Manchester and Stockport. Malling-Hansen's (497) study of food values in Copenhagen gave in general negative results. Pagliani's (574) Italian study appeared in 1879. Landsberger's (457) study of boys appeared in 1888. Kozmowski's (448) intensive work on the weight and growth of children of the poorer classes of Warsaw is dated 1894. From 1899 to 1902 Pfitzner (592-594) published a series of "Social Anthropologische Studien". Niceforo (549) 1903, began a study of over 3,000 children in the schools of Lausanne, classified according to social status. Koch-Hesse (445) 1905, compiled much statistical material from various investigators. Allaria (5) 1912, investigated the growth of children of the poorer classes. Young (900) 1913, found the children of the rich to be better developed than children who attended public schools. Elderton (229) 1914, classified the measurements of over 63,000 Glasgow school children in four social groups. Dikanski's (211) 1914, arrangement of Hoesch-Ernst's material showed better physical development with rising social class. Brezéjinski and Peltyn (123) measured children of factory workmen, 1914. Frankel and Dublin (263) 1916, analyzed the measurements of 10,000 children who received employment certificates in New York City during the previous year. Schlesinger (713 and 714) 1917, again proved the superior development of the children from well-to-do families. The measurements by Baldwin (27) 1914 and this Study, on children of the well-to-do class are on the whole extremely high.

D. CITY VS. COUNTRY LIFE

Although many studies of school children in and around certain cities would probably permit of comparisons of the physical development of city and country children, if the original data were at hand, there have been few studies undertaken directly for this purpose. The question of stature in the city and country population was discussed by Quetelet (626) in 1830. Galton (279) 1873-74, and Peiper (583) 1912, found country boys to be both taller and heavier than city boys. Baldwin (28) 1916, obtained results that were in agreement with this, inasmuch as it was found that country boys mature earlier than city boys. Pyle and Collings (624) 1918, found that there was a slight difference in favor of city children. Urlick (831) 1918, presented statistics on city and country children in Iowa.

Doubtless the War Departments of various countries are in possession of much material on this point, but little has been published. The statistics of men drafted in the United States during the World War,

[illegible]

which were analyzed by Davenport and Love (200), showed that 61.74% of urban men were accepted without defect, rural 66.74%, and that 33.49% of urban men were accepted with defect, rural 28.30%.

E. HYGIENE AND EXERCISE

A great deal of work on physical growth has been approached from the point of view of hygiene. Measurements of children have often been undertaken in order that school desks might be better adjusted to the physique of the children. Other studies, especially in Germany and Russia, have been made with the purpose of ascertaining the effect of school conditions on the physical development of children. A third group deals with the effect of exercise, physical training and college athletics. Other investigations are concerned with general health, diseases and physical defects.

Many of the references on physical hygiene are classified under other specific subjects, since the field is comprehensive and indefinite, but those of particular import limited to the influence of hygienic conditions are: Hutchinson's (409) 1846, and Pagliani's study (573) 1875, with particular reference to breathing capacity; Roberts' (662) factory report, 1876, and his memorandum on medical inspection (660); Kotelmann's (449) 1879, study on the influence of physical training; Bruun's (131) study in hygiene, 1887; Geissler and Uhlitzsch's (291) study on fitting school desks, 1888; Kellogg's (426) strength studies, 1896; Porter's (616 and 617) 1896, measurements in schools; Taylor's discussion of the influence of exercise upon length of life (804) 1897; Burk's (138) Influence of Exercise, 1899; Burgenstein's (135) Schulhygiene, 1902; Hastings' (357) Health and Growth of School Children, 1903; sketches of English school children by Thomas (815) 1905; Zahor's (902) Prague study, 1907; Tyler's general articles (828 and 829) 1907 and 1908; Harrington's (348) Health and Education, 1910; Wright's (895) Post-Adolescent Girls, 1910; Baldwin's (259) Notes on School Observation, 1911; Pyle's (622 and 623) manuals of 1913 and 1920; Terman's (807) Hygiene of the School Child, 1914; the comprehensive investigations by Tuxford and Glegg (827) 1911, including 583,640 English children between three and 14 years of age; Mumford's (543) 1912, Manchester grammar school investigation; with the additional English studies of Greenwood (316) 1915, and Tuxford (826) 1917; Penn (586) 1917; and Kerr (427-428) 1918 and 1919. In Germany appeared Meumann's (521), Experimentelle Pädagogik, 1911; Heller's (364) studies on Salzburg children, 1913-14; Steinhaus' (776) 1913; Spitzzy's (771) Die körperliche Erziehung des Kindes, 1914; and Matthias' (507) 1916, work on the effect of physical exercise on Swiss athletes. Laurent's (467) investigation of physical education in France; and the important Russian studies cited by Sack, i.e., Leshaft (471) 1879-80, Nagorsky (548) 1881, Michailoff (523) 1887, Belyaieff (48) 1888, and Zhbanks (910) 1889.

F. SPECIAL CONDITIONS

A number of isolated investigations deal with the relation between growth and other special conditions not previously listed in this resumé.

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B. HYGIENE AND ...

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other ... but ... conditions ... of ... school ... (1910 and 1911) ... Influence of ... (1910) ... of ... stand ... Absorption ... of ... 14 years of age ... reason ... (1910) ... In Germany ... Heller's ... 1910; ... (1910) ... and the ... 1910-1911 ... and ...

C. SPECIAL ...

A number of ... growth and ...

Among these is an investigation of loss of weight and gain in height during sleep, by Curtiss (186) 1898. Burk (137) in 1899 discussed the influence of sex on growth. Cailli (142) 1903, noted the effect of country living. Boas (94) 1909, published an article on civilization and stature. The work of Davenport reported in his Heredity in Relation to Eugenics (198) 1911, and his Inheritance of Stature (199) 1917, continued a line of investigation begun by Galton. Carmon (159) 1912, published a discussion of rapid changes in weight. Boas (99) 1913, traced the effect of heredity and environment on growth. Reports on growth and dentition were made by Bean (42) 1914, and Spier (769) 1918. Stiles and Wheeler (782) 1915, analyzed physical measurements of American children from homes of good and poor sanitary condition. Camescasse (155 and 156) 1918, reported the results of an experiment in which for the sake of economy bread was replaced by rice and vegetables, with good results. In 1919 Dick (206) published in England his book on the effect of defective housing on growth. Powys (621) 1902, and Harris (349) 1920, have noted the decrease in stature in later adult life. Retan (652) and Emerson (234) have been particularly interested in the relation between nutrition and physical development.

8. SPECIAL AND ABNORMAL PHASES OF GROWTH

A. PATHOLOGICAL

A limited number of good scientific studies has been made on the relationship between growth and disease. In 1881 Bowditch (111) asserted that the "normal rate of growth would not only throw light on the diseases to which childhood is subject, but would also guide us in the application of therapeutic measures." One of the earliest treatises was by Regnier (650) 1860. Then came Auboyer's (20) work in 1881. Hertel (368) 1882, published the report of the Danish Commission including measurements of 17,595 boys and 11,646 girls. In 1885 appeared his Overpressure in the High Schools of Denmark (369), and in 1888 a comparison between the findings of the Danish and Swedish Commissions (370). Key's (430) important Stockholm study appeared in 1885 and the German edition in 1889; Michailoff's (523) Russian study, 1887; Springer's (772) 1890; Carlier's (158) 1892; Bezy's (66) 1894; Combe's (175) investigation in Lausanne, 1896; Warner's (856) comprehensive English study, 1897; Schmid-Monnard's (721) German study in 1897; Ranke's (646) German study, 1905; Camerer's (151) investigation of malnutrition, 1905; Gunðobin's (331 and 332) Russian investigation of Basedow's disease on stature, 1909-10. Other important contributions are Camerer's (152) general account of growth in relation to disease, translated 1908; Baldwin's (25) Notes on School Observation, 1914; Chose's (169) 1914 work on rachitis and growth; Thiele's (810) 1915 on tuberculosis; Schiotz's (702 and 703) articles on growth and disease, 1915 and 1916; and Strong's (795) study of the effect of hookworm, 1916. Many general texts on children's diseases contain chapters on growth. Among those not previously mentioned is that by Feer (250) 1911. Kotz (450) 1918-19 discussed the phenomena of unequal growth of the two sides of the body, and Thoma (814) 1918, the conditions that interfere with the growth of the head.

B. MENTAL ABNORMALITY

From the standpoint of developing standards for the physical growth of normal boys and girls, valuable facts have been obtained through comparison with the growth of feeble-minded children. The first study dealing with the physical growth of idiots and imbeciles (mentally deficient children) was published by Roberts (663) in the manual on Anthropometry, in 1878. The investigation, which was probably made in 1871, included the height and weight of 829 children and adults between the ages of three and 15 years, from the asylums in England, without differentiating between the sexes. In 1877 Shuttleworth (752) published in America a very good paper on the growth and mentality of feeble-minded children. Tarbell's (801 and 802) studies appeared in England, 1876-86 and 1888-89. Wylie (897 and 898) 1899 to 1903, made careful studies of 400 boys and girls from Minnesota and concluded that feeble-minded children were subnormal in physical development, while Macdonald (490) 1897-98, also found children with abnormalities inferior in growth to children in general. Binet's (68-71) significant studies appeared in France in 1900 to 1910. A later book with Simon (72) was translated, 1914. Simon's (761 and 762) studies appeared 1899 and 1900; Vaney's (833 and 834) 1906-1909, and Martin's (504) in 1912. Norsworthy (553) 1906, could find no distinguishable differences between the physical development of feeble-minded and normal children compared with the Boas and Bowditch standards. Guttmann (333) reported comparative measurements of normal and abnormal children in 1906. Goddard (297) 1912, has made the most valuable and painstaking study within this field, having recorded measurements on 10,000 children at the Vineland Training School in New Jersey and at eighteen other institutions in America. Doll (212) 1916, used the psycho-physical measurements of right and left grip and lung capacity as diagnostic criteria of feeble-mindedness, and Porteus (619) 1919-20, has been making careful studies in cephalometry of the feeble-minded children at Vineland.

Among the special studies of physical development of the insane, should be mentioned Boyd's (114) 1861, studies on 2614 post-mortem examinations. Goodall (308 and 309) 1898 and 1901, compared the development of the insane and the abnormal. The physical development of delinquents has not received much attention, though several medical studies have been made. The best work in the anthropometric field is that by Marty (506) 1898, and by Tallant (800) 1912.

9. PHYSIOLOGICAL AGE

A. ADOLESCENT GROWTH

One of the most important present-day problems in physical growth from the standpoint of the educational, social, religious and psychological development of the child centers around the question of physiological age, with particular reference to the development during adolescence. In his early work, 1890, Key (432) raised the problem of "Die Pubertätsentwicklung und das Verhältnis derselben zu den Krankheitsercheinungen der Schuljugend." In 1891 Key (433) made another contribution to the subject, as did Miwa (529) 1893. Morey-Errant (538) 1898, published a general discussion bearing primarily on puberty; Lincoln (477) 1896, published a practical paper with some good observations on sexual maturity; Moon (536) 1899,

printed a short paper with a discussion of the question of growth and puberty, claiming that the latter had no effect on growth; Godin (298, 301, 302) in 1902, 1911 and 1912, published brief papers on the adolescent type, based on his 1903 study (299), with 36,000 measurements on the same one hundred subjects followed from 13 to 18 years of age. In 1902 and 1907 Wiazemsky (877 and 878) published important studies on modifications of the organism during the period of puberty. Kimpflin (436) 1914, reported measurements of 200 adolescents. Riebesell (655) 1916, proposed that weight as a function of time should be used as an index of physiological age.

B. PHYSIOLOGICAL AGE AND SCHOOL PROGRESS

The educational and sociological significance of the problem of physiological age has been championed by Bryan (132) 1900; Crampton (181-184) 1908; Weissenberg (865) 1911; Foster (261) 1910-11; Boas (98) 1912; Beik (46) 1913, and Baldwin (27 and 28) 1914 and 1916, Bean (42) 1914, reported on the relation between dentition and maturity, while Rotch (675 and 676) 1910, initiated the problem of the graduations of carpal and epiphyseal development. The question of adolescence in its psychological, sociological and educational bearings, together with comparative data from various investigations on physical development, has been treated by Hall (340) in his Adolescence, 1904.

10. PHYSICAL GROWTH AND MENTAL DEVELOPMENT

A most significant trend of investigations on physical growth, from the writer's point of view, lies in the large number of studies dealing with the relationship between physical and mental development. Modern genetic, functional and behavioristic psychology all begin with the phenomena of physical growth. Warner's (855) 1890, very comprehensive but inaccurate study, served to initiate the problem in England. Other studies which contain material bearing on this problem, but usually not analyzed to show the exact relation between physical and mental development, have been made by Martiegka (502) 1898; Thorne (819) 1904; Berry (58) 1904; Quirsfeld (635-637) 1904-1907; Samosch (687) 1904; Eyerbibh and Lowenfeld (243) 1905; Popper (610) 1907; Arkle (15) 1908; Vaney (833-834) 1906 to 1909; and Albert and Arvizu (3) 1917. Burk (136) 1898, Oppenheim (563) 1898, Hall (340) 1904, Thorndike (817) 1901, Whipple (874) 1915, and Kirkpatrick (440) 1917, analyzed and summarized the general problem more or less extensively without original data.

A. ABSENCE OF CORRELATION

A number of investigations have shown no discernible relationship between mental and physical development. So, for example, Galton (287) 1891, in university tests found no correlation between literary ability and physical measurements. Gilbert (294 and 295) 1895 and 1897, and Cattell and Farrand (163) 1896, found no definite correlation between physical and mental tests. Radosavijevich (639) 1913, also could trace but little correlation between physical development and school brightness. The work of Pearson (577-579) 1901-02, and 1906, and of Lee, Lewenz and Pearson (469) 1903-04, showed very small and unreliable correlations between intelligence and physical characters.

B. NEGATIVE CORRELATIONS

Only one investigator definitely states a negative correlation. This is Sargent (693) 1908, who found that the "stipend scholarship men" at Harvard were among the shortest and lightest.

C. POSITIVE CORRELATIONS

The most significant pioneer study showing positive correlation was made by Porter (611-618) 1892-93, 1894 and 1896, who found that "precocious children are heavier and dull children are lighter than the mean children of the same age." Holmes (394) discussed this work in 1894 and Boas (86) in 1895. Positive findings have been confirmed or supplemented as follows: in Russia by Gratsianoff (313) 1889, and Sack (681) 1892, -- in America by Hartwell (351) 1894-95; West (873) 1896; Macdonald (490-492) 1897-98 and 1910; Hastings (355) 1899; Christopher (171) 1900; Smedley (764) 1900; Beyer (65) 1900; Zirkle (911) 1902; Debusk (203) 1913; Mead (513) 1914; Grover (325) 1915; Donaldson (215) 1915; Stewart (780) 1916; Busk (140) 1917; Curtis (179) 1917; and Baldwin (25, 27 and 30) 1911, 1914 and 1920, -- in Germany by Schmidt and Lessenich (725) 903; Graupner (314) 1904; Bayerthal (40) 1905-1910; Reitz (658) 1906; and Spielrein (768) 1916.

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